GSA RAY PV/Wind

feasibility report

10.14.2009

GSA

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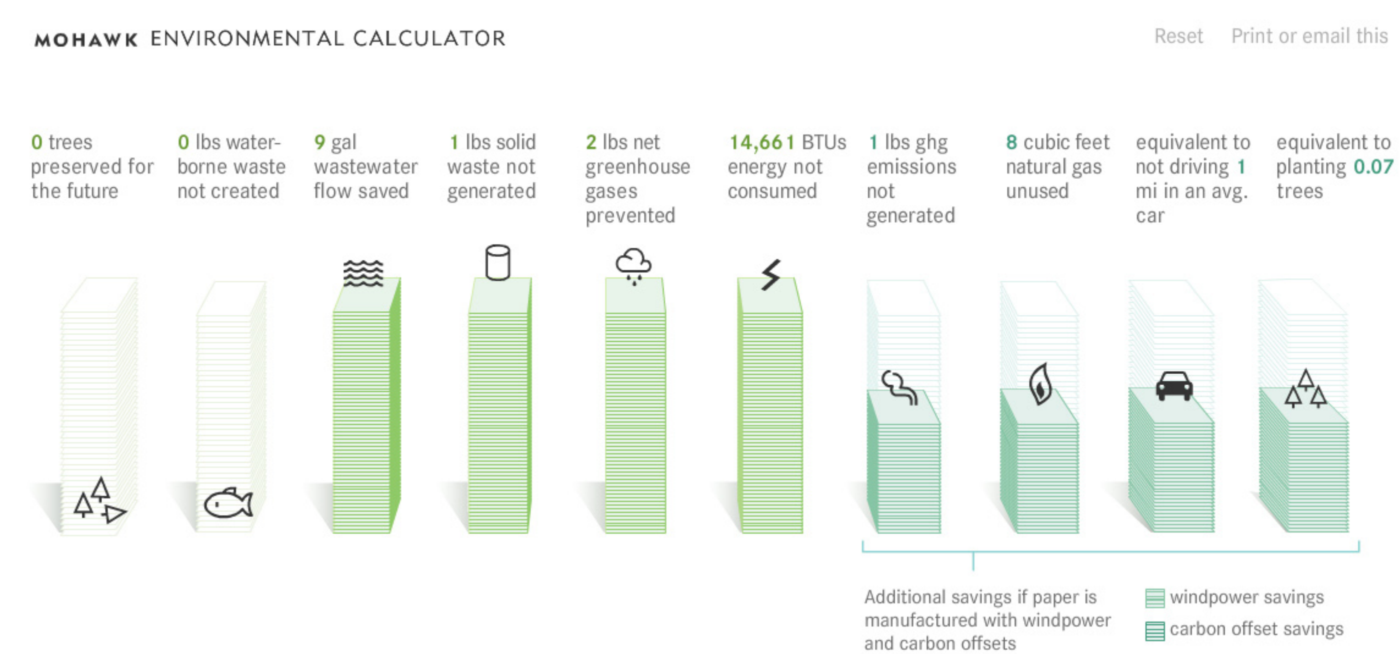


Environmental Savings for GSA RAY PV/Wind Analysis

☐ This booklet was printed on Mohawk 100% FSC certified recycled paper, made with 100% wind power introduction

Section 1

existing conditions and analysis

Lower Roof (concrete deck)

Existing Roof structure: Concrete Deck

Reroofing Project:

Added lightweight insulating concrete with integral Extruded Polystyrene (EPS) tapered insulation, Base Sheet applied on top.

Roof membrane is a 3-ply (for foot traffic) torch-down SBS Modified bituminous roof manufactured by the Garland Company, installed in 2002, 2003 with a 30 year warranty.

Roof has a cool roof coating installed in: 2005

A.WHITE REFLECTIVE COATING

1.Pyramic: White non-toxic, fire retardant roof coating formulated from water-base, pure acrylic, self curing latex polymers.

Properties:

Color:	White
Reflectivity:	81%
Density:	12 lb per gallon
Elongation:	250% minimum
Tensile Strength:	250 psi minimum
Coverage Rate:	1.5 gallons per square per coat

Penthouse Roof (AHUs)

Existing substructure is metal decking over steel bar joists and part of pre-engineered AHU enclosure.

Reroofing Project:
Added a tapered Isocyanurate insulation over the decking
Roofing is a low profile metal roof product by Garland called R-mer lite and is a low slope application that comes in 4' to 10' sections and has a compression seam bar at overlaps and is attached to 20 gauge hat channels. (less expensive application than standing seam metal roof).
This roofing system is very lightweight at only ⅜ lb/SF.

Penthouse Roof ()

Existing substructure metal decking over steel joists
Reroofing Project:
Added a tapered Isocyanurate insulation over the decking.
Roof membrane is a 3-ply (for foot traffic) torch-down SBS Modified bituminous roof manufactured by the Garland Company, installed in 2002, 2003 with a 30 year warranty.

Roof has a cool roof coating installed in: 2005 (same system)

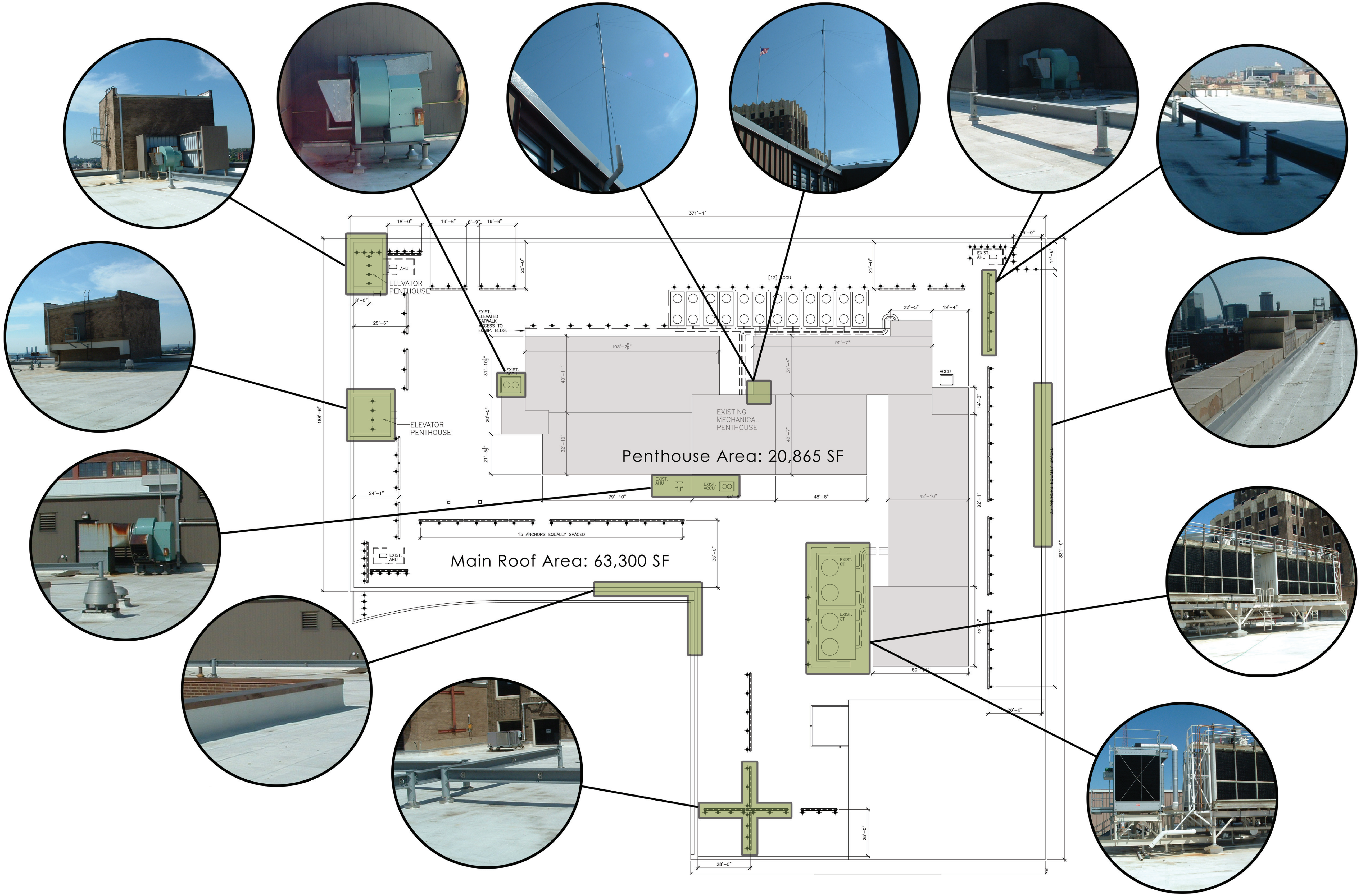
ROOF WARRANTY

30 year warranty (Tom Yochim has copy)

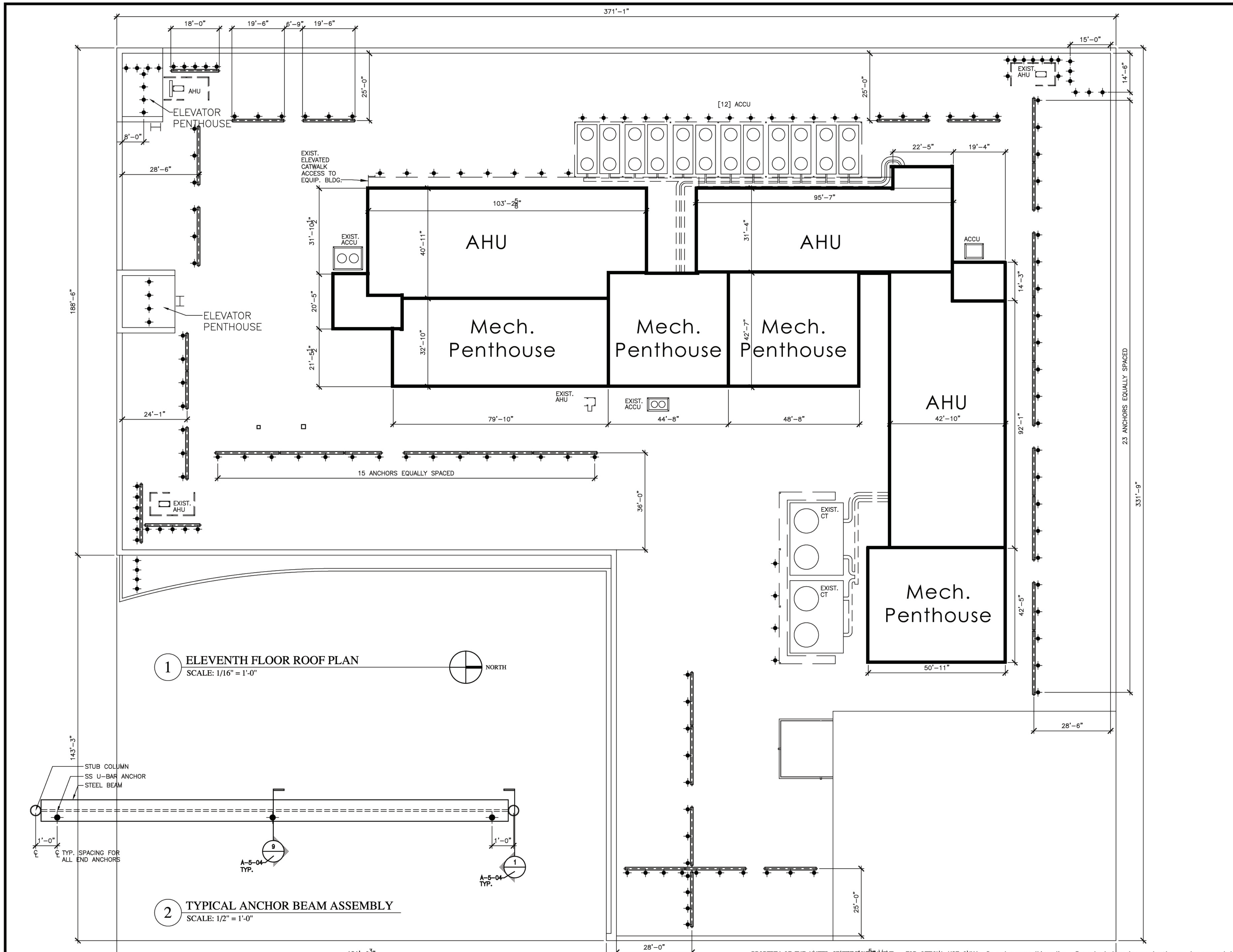
1. Anticipated Replacement Date
   In 25 years after warranty expires

2. Installed Cost
   $2,500,000-3,000,000

existing roof plan



existing penthouse roof plan



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GSA
GENERAL SERVICES ADMINISTRATION
Heartland Region
Public Buildings Service
1500 East Bannister Road
Kansas City, Missouri 64131-3088

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CERTIFICATIONS

KEY PLAN

LIMITS OF WORK: ROBERT A. YOUNG BUILDING

REVISION NOTES

MARK	DATE	DESCRIPTION

GRAPHIC SCALE 16' 8' 0 8' 16' 32' 1/16"=1'-0"

CONTRACTORS	A/E CON. NO.	GS06P02GYD0048
	A/E TASK NO.	12
	CONS. CONTR.	
	CONS. WORK	
	PRIME A/E	TEAM FOUR ARCHITECTS, INC.
	SUB A/E	
	CONSTR. CON.	
BUILDING	NAME	ROBERT A. YOUNG FB
	STREET	1222 SPRUCE STREET
	CITY/ST./ZIP	ST. LOUIS, MO 63102
	BUILDING NO.	MO0106ZZ
	OTHER BUILDING NOs.	
	FACILITY CODE	
PROJECT	PROJECT TITLE	ROBERT A. YOUNG FB ROOF ANCHORS
	PROJECT DESCRIPTION	ADDITION OF EXTERIOR ROOF ANCHORS
	PROJECT NO.	RMO25301
	GSA PM	JEFF MEYER
	SUBMISSION	BID DOCS
	SUB. DATE	05/24/2005
DRAWING	DRAWING TITLE	11th FLOOR ROOF PLAN
	FILE NAME	A-RP11.DWG
	FLOOR NO.	11th FLOOR
	DRAWN BY	GMP DATE DRAFTED: 05/23/2005
	CHECKED BY	WA SHEET SIZE: 24 X 36
	DRAWING NO.	A 1 01 (DISCIPLINE, SHEET TYPE, SEQUENCE)
	SHEET	2 OF 4

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The Pyramic coating is a white, non-toxic, fire retardant roof coating formulated from water-based, pure acrylic, self-curing latex polymers. It also contains unique “bleed-blocking” polymers that make it very suitable for use over asphaltic surfaces. It is designed for application by brush, roller or spray.

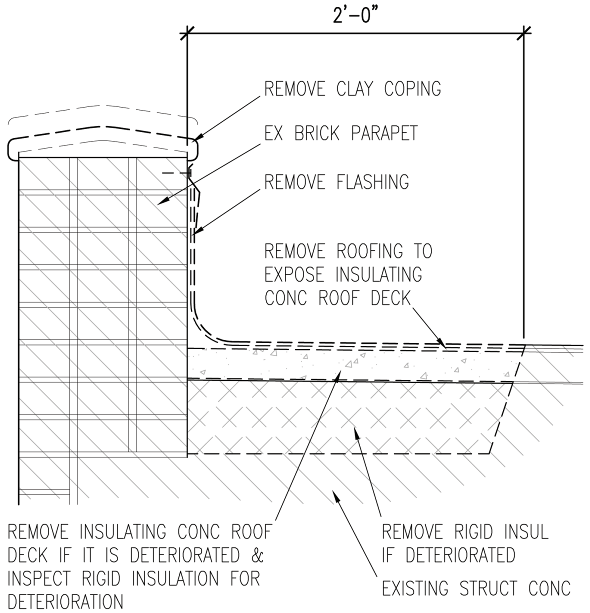
Pyramic coating on main roof

Technical Data

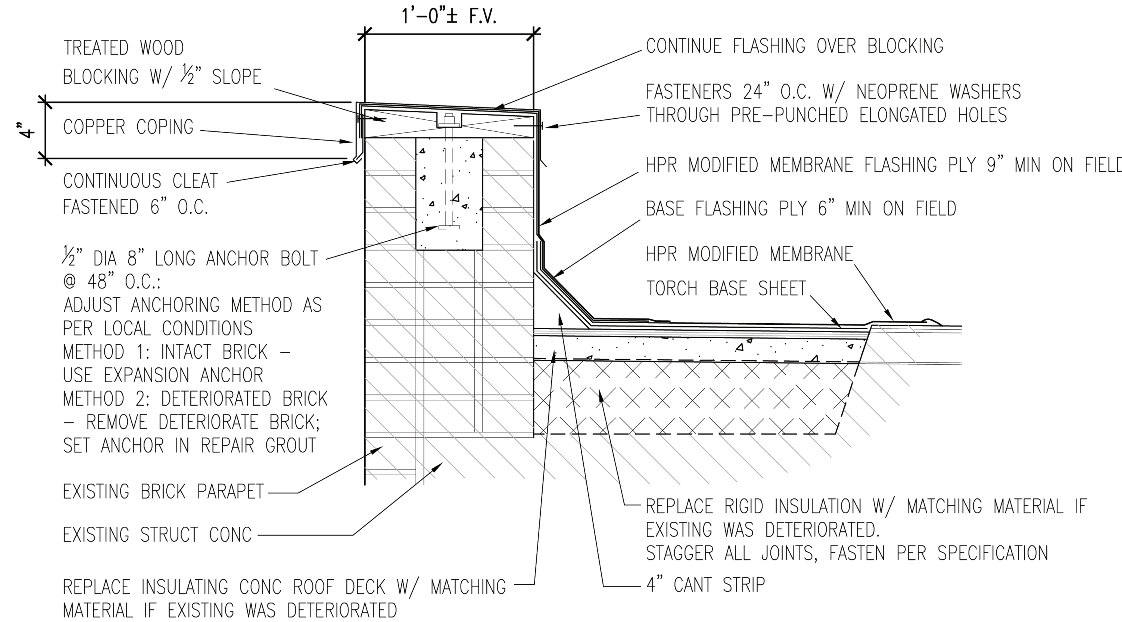
VOC Status	70 g/l
Shelf Life	1 year
Coverage	2 gal./100 $ft.^2$ (.82 l/m^2) Two coat application
SRI	101
Reflective	Typical 81%
Emittance	94

EPA Cool Roof on R-Mer-Lite panels

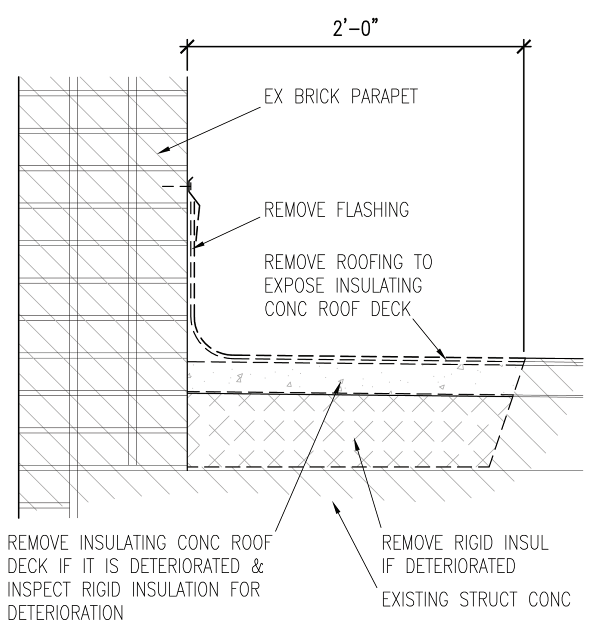
parapet details



1 TYP **CLAY COPING/ROOFING/FLASHING DEMOLITION**
1 1/2"=1'–0"



2 TYP **COPPER COPING/ROOFING/ FLASHING DETAIL**
1 1/2"=1'–0"



3 TYP **MASONRY/ROOFING/FLASHING DEMOLITION**
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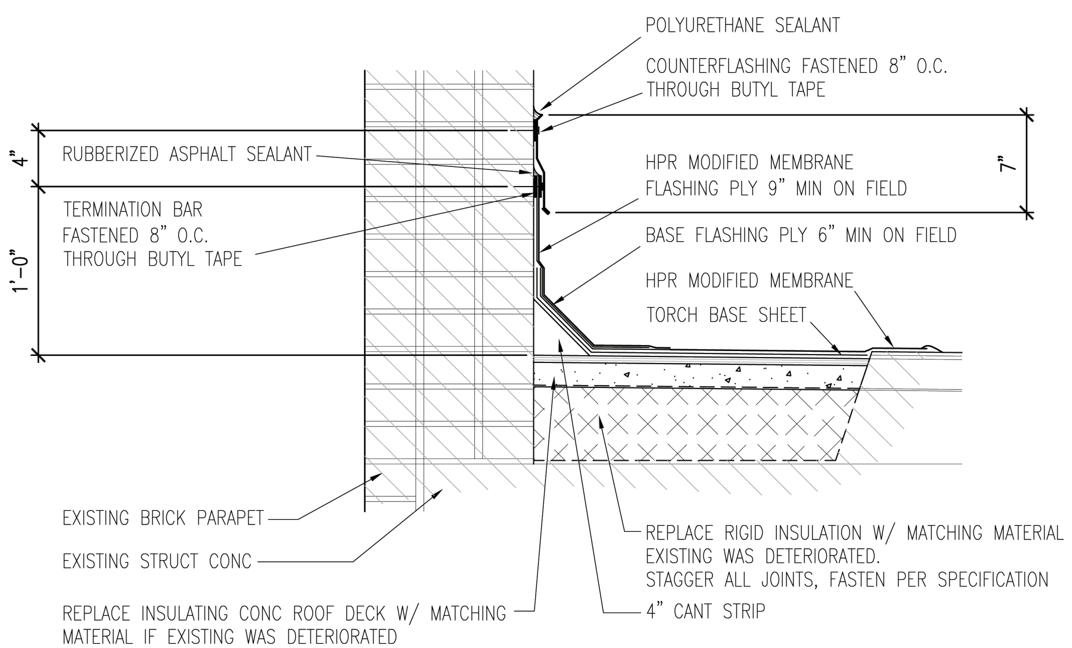


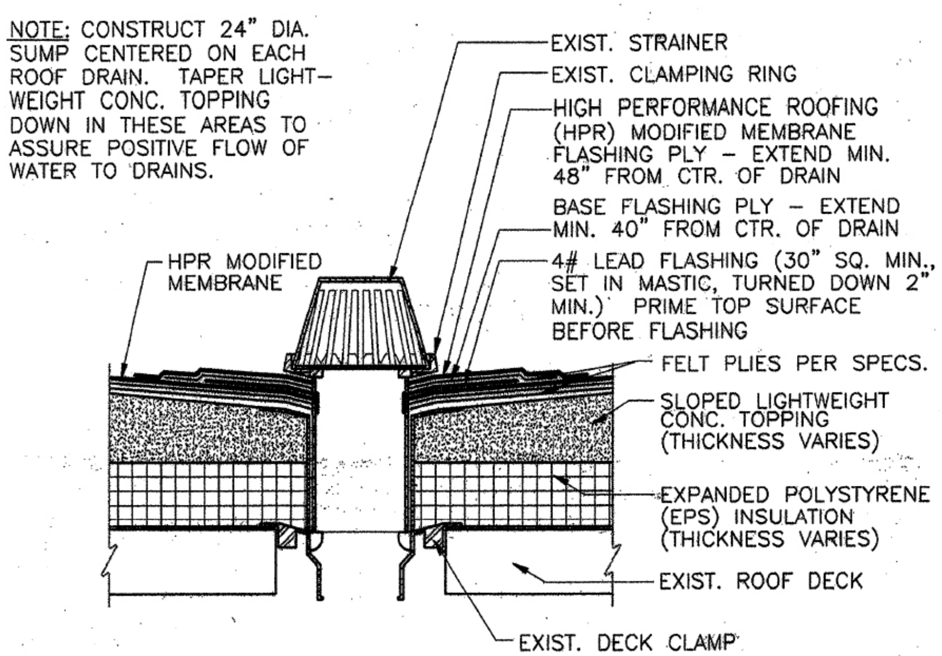
4 TYP **MASONRY/ROOFING/FLASHING DETAIL**
1 1/2"=1'–0"

Historic Parapet

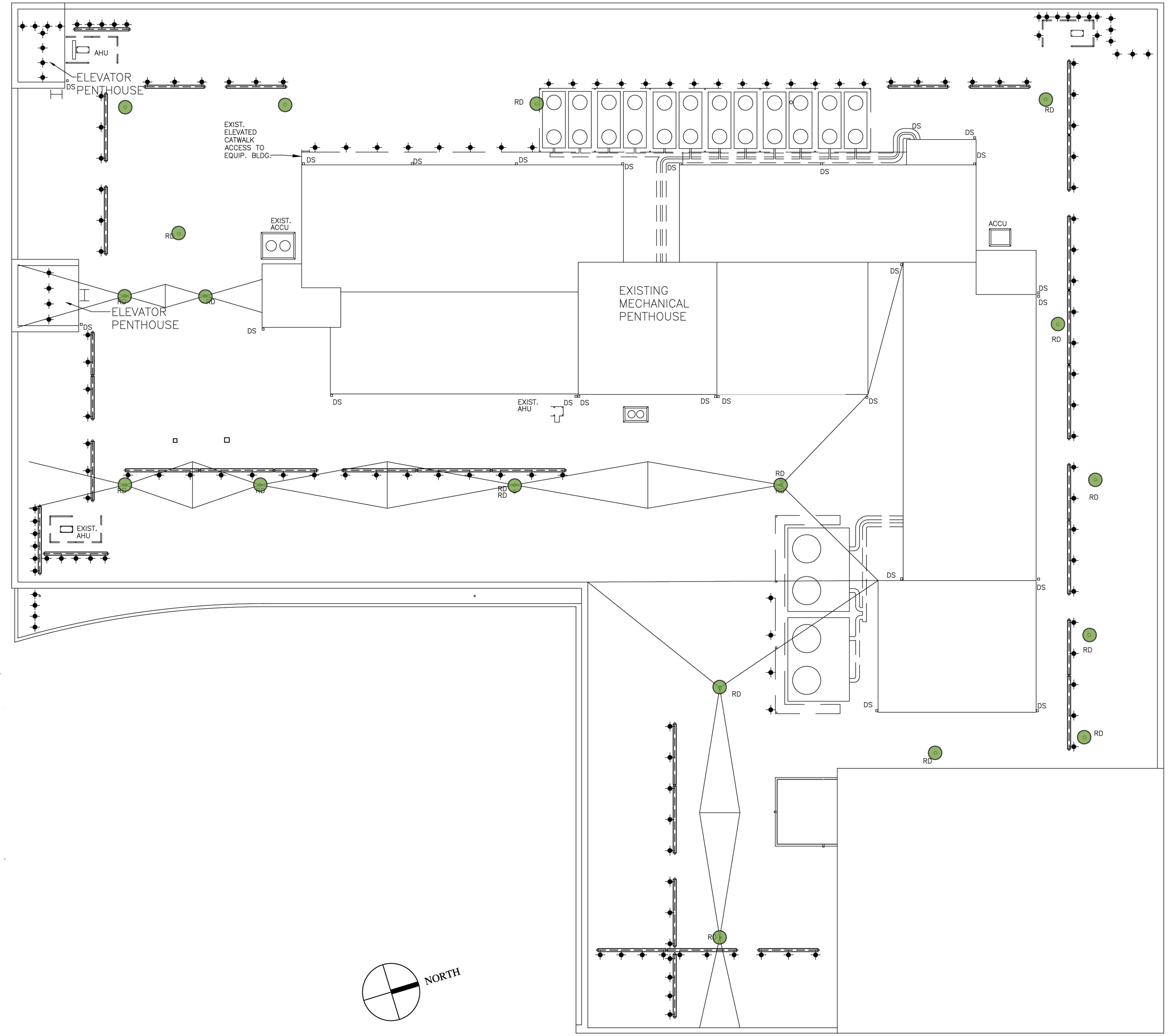
South Facade Parapet

roof drainage

Typical Roof Drain



Typical Roof Drain Penetration



Roof Drainage Plan

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www.OSHA.gov
Safety and Health Regulations for Construction
Duty to have fall protection. - 1926.501

1926.501(b)(1)
"Unprotected sides and edges." each employee on a walking/working suface (horizontal and vertical surface) with an unprotected side or edge which is 6 feet (1.8 m) or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems.

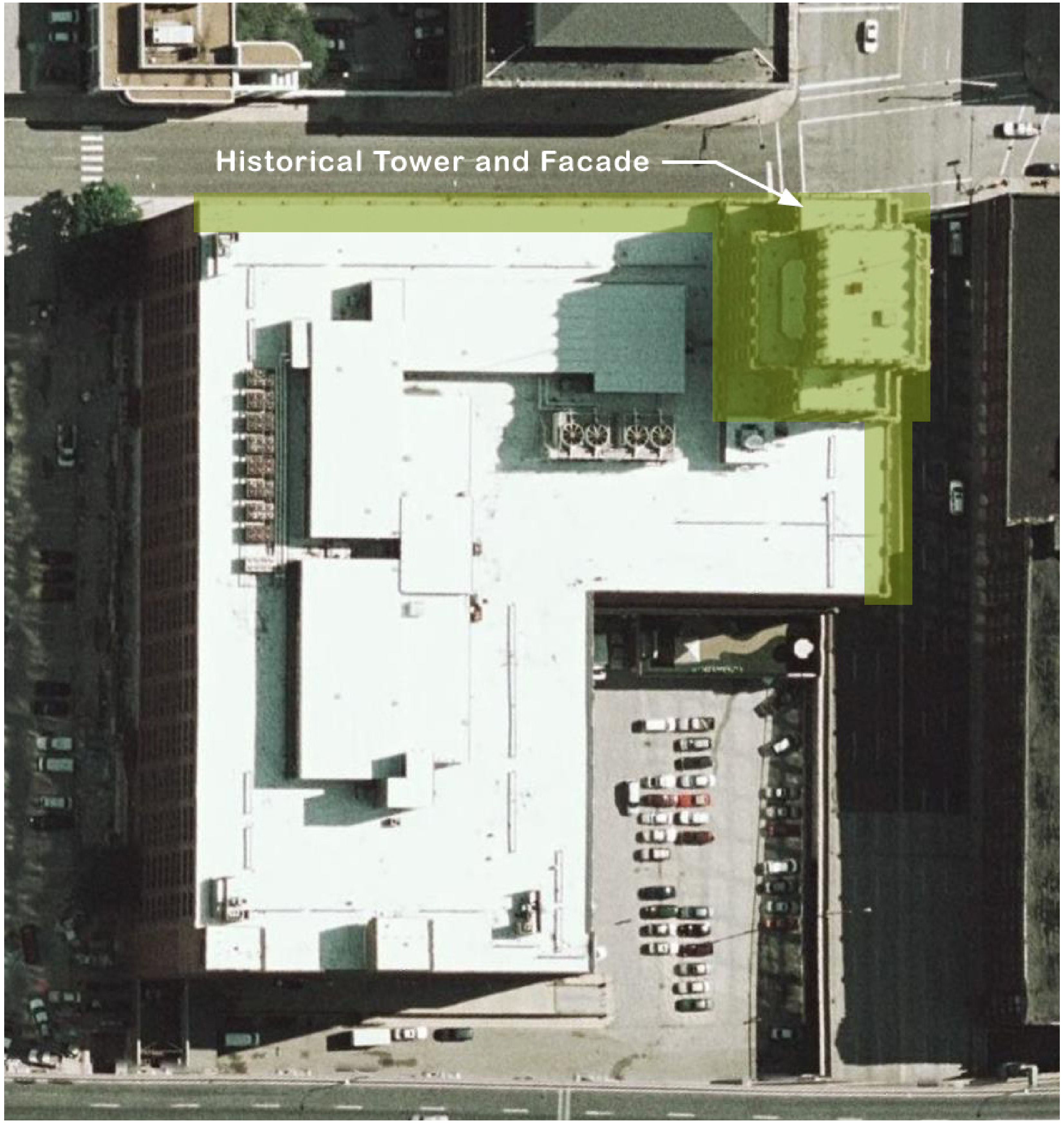
1926.501(b)(10)
"Roofing work on Low-slope roofs." Except as otherwise provede in paragraph (b) of this section, each employee engaged in roofing activities on low-slope roofs, with unprotected sides and edges 6 feet (1.8 m) or more above lower levels shall be protected from falling by guardrail systems, safety net systems, personal fall arrest systems, or a combination of warning line system and guardrail system, warning line system and safety net system, or warning line system and personal fall arrest system, or warning line system and safety monitoring system. Or, on roofs 50-feet (15.25 m) or less width (see Appendix A to subpart M of this part), the use of a safety monitoring system alone [i.e. without the warning line system] is permitted.

Regulatory

The Robert A Young Building, being a federal government facility, is not subject to local zoning and building codes. Nevertheless, in the interest of being a good member of the community the local codes and ordinances are taken into consideration.

Zoning: The zoning ordinance does not specifically address the issue of wind turbines or photovoltaic (PV) panels on the roofs or on the building. It seems that the ordinance predates this as a possible issue and there have been no modifications to the ordinance addressing this topic. The zoning administration indicates that they have no objection to adding equipment to the roof for green initiatives. The Mayor's Office has come out strongly in support of green initiatives. Zoning sees turbines and PV panels no differently than any other equipment that is roof mounted. The height restrictions in the zoning ordinance do not preclude roof mounted equipment that extends above the height limitation.

Building Code: The IBC 2006 does not specifically address wind turbines and PV panels. It treats these components the same as any other roof top mounted equipment. The code requirements for roof top mounted equipment that requires service indicates that they have to be set back from a roof edge by 10' or there needs to be a 42" high protection at the edge.



Historic

The Robert A. Young building was constructed in 1933 as a warehouse for the Terminal Railroad Association. After the original construction the warehouse portion of the building was expanded adding the top three floors. The construction is noticeably different with the exposed spandrel beams. In 1941, the government acquired the property for the Department of the Army. The property was transferred to GSA in 1961. The building was designed by Preston J. Bradshaw a noted St. Louis architect. The building façade features decorative terra cotta walls, inlays, ornamentation and parapet copings. The Robert A. Young Building is eligible for listing on the National Register of Historic Places. The north and east facades are the street facades that have the ornamentation and the most historical significance. The south and west facades are the warehouse facades but they are now highly visible from the elevated interstate to the south.

GSA has an individual that is a specialist on historic buildings. This person works with the State Historic Preservation Officer to reach an understanding of what can and can not be done on specific buildings. If turbines and PV panels are to be added to the building GSA will handle communications with the State of Missouri to verify that the intended installation of equipment is acceptable with respect to historic concerns.

The visibility of the proposed roof top mounted equipment is limited. The expectation is that it would not be an issue relative to historic nature of the structure. This has to be confirmed. The visibility of the wind turbines from the interstate will be a topic of discussion but the south and west facades are not the primary historic facades.

South Facade

South Facade

South Facade

This report is offered to describe basic information about the various roof framing systems of the Robert A. Young Federal Building (RAY Building) and how these roof systems may be affected by additional loads resulting from the installation of different types of renewable energy equipment. Preliminary cost estimates have been developed for the structural support and reinforcing required to provide support for new equipment on the existing roof.

RAY Building Structural Systems

The RAY Building is a concrete structure that was built in two phases over a period of approximately twelve years. The original construction dating from 1930 consisted of a 7-story building with a roof designed as a future 8th floor. In the northeast corner of the building the tower portion continued up an additional twelve floors plus a roof. In 1942 three additional levels of construction were added to the low-rise portion of the building. The existing roof was transformed into the current 8th floor, and floors 9 and 10 were added along with a new roof at the 11th floor level. The building structure is of reinforced concrete construction that appears to be in good condition. The typical floor construction for the low rise portion of the building is a flat slab system consisting of 9" thick floor slabs with drop panels and capitals around the columns. The roof construction is a 6-1/4" slab with drop panels and column capitals.

There are mechanical penthouses on the roof that were added as part of a building modernization project in the late 1980's. These penthouses are framed in structural steel with metal roof decks. The majority of penthouse framing was observed to be steel bar joists bearing on wide flange steel beams and columns. In some penthouse areas the steel joists are supported on concrete masonry unit (CMU) bearing walls. These CMU walls also provide lateral stability for the penthouse structures. It was noted that the penthouse roof framing does not carry significant piping or mechanical systems in the accessible areas that were observed.


Mechanical Penthouse Interior

Along the southern edge of the low-rise portion there are two additional penthouses that were originally constructed over elevator shafts and machine rooms. These elevators were removed during the building modernization in the late 1980's and the shafts were filled in with framed slabs at the floor levels. The original penthouse roofs that have remained were constructed with reinforced concrete slabs and joists and perimeter concrete beams.

The total area of penthouse roofs above the 11th floor/roof is approximately 22,000 square feet. Of this total area, a little less than 13,000 square feet (approximately 59%) is actually the roof area over custom built air handling units (AHU's). Another 1,000 square feet is the concrete joist framed roofs that remain over the previous elevator shafts along the southern edge. The remaining 8,000 square feet comprises the penthouse areas that are framed with structural steel beams and joists bearing on small wide flange columns and CMU walls.

Available Documentation

A nearly complete set of drawings is available for the original phase of construction that comprised the first 7 floors and the original roof (current 8th floor). These drawings are scanned images of copies of the originals and are not completely legible. Large areas of the drawings are too light to read and information could not be obtained.

An incomplete set of drawings for the 1942 addition of the 9th and 10th floors and the existing 11th floor/roof construction is also available. Again, the drawings that are available to review are difficult to read. More importantly, the reinforcing steel schedules for the roof slabs and beam framing are not included in the drawing set. This does not permit quantitative evaluation of the impact of new roof loading imposed by the renewable energy source equipment. However, existing drawing S5 is partially legible and it shows the penthouse framing with reinforcing over elevator shafts along the southern edge.

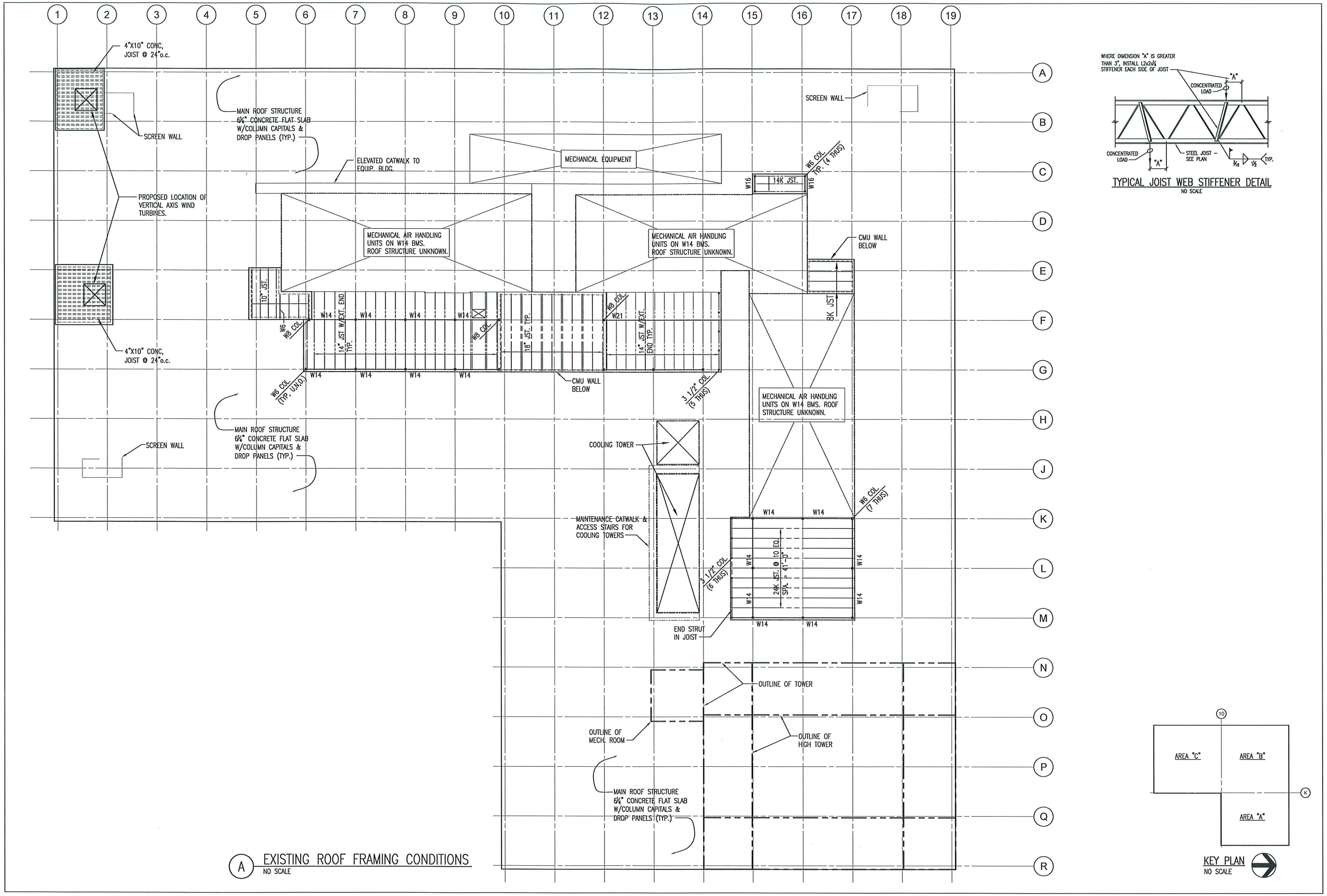
Complete sets of drawings are available for the 'Penthouse and Roof Construction' and 'Building Modernization' projects that were built in the late 1980's. These drawings show the roof framing for penthouse areas framed using steel joists and wide flange beams or CMU walls. However, information is missing for the roof area over the custom built air handling units. These roofs are part of the

Mechanical Penthouse Ceiling

AHU cabinet that was custom designed and built by the mechanical contractor. It may not be possible to determine the capacity of the AHU roof area unless the original drawings of the air handling equipment could be located.

New Renewable Energy Equipment

Photovoltaic solar panels and wind turbines are both being considered as renewable energy sources for the RAY Building. Structural implications of the different systems are described in the following sections.



Existing Conditions

structural conditions

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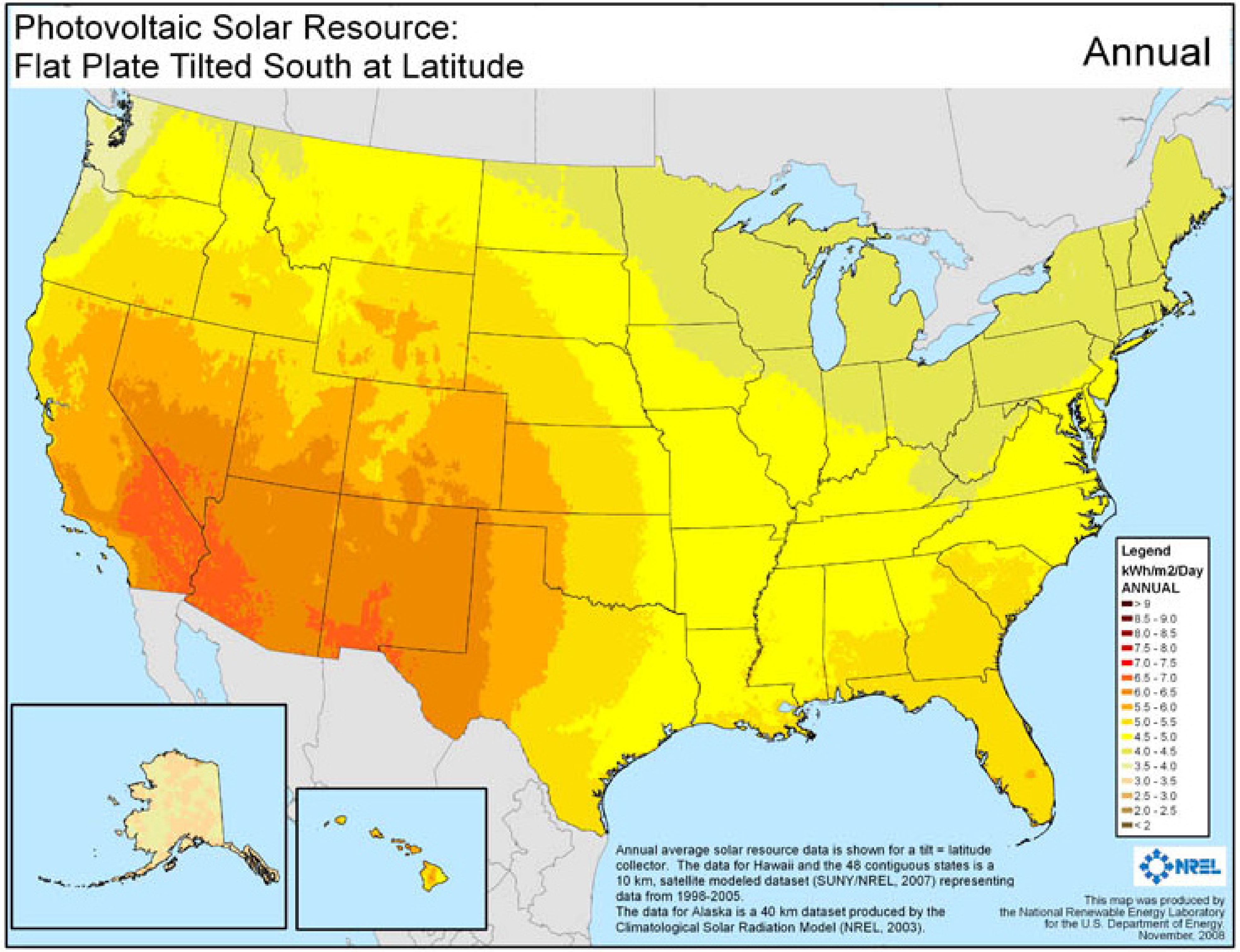
Section 2

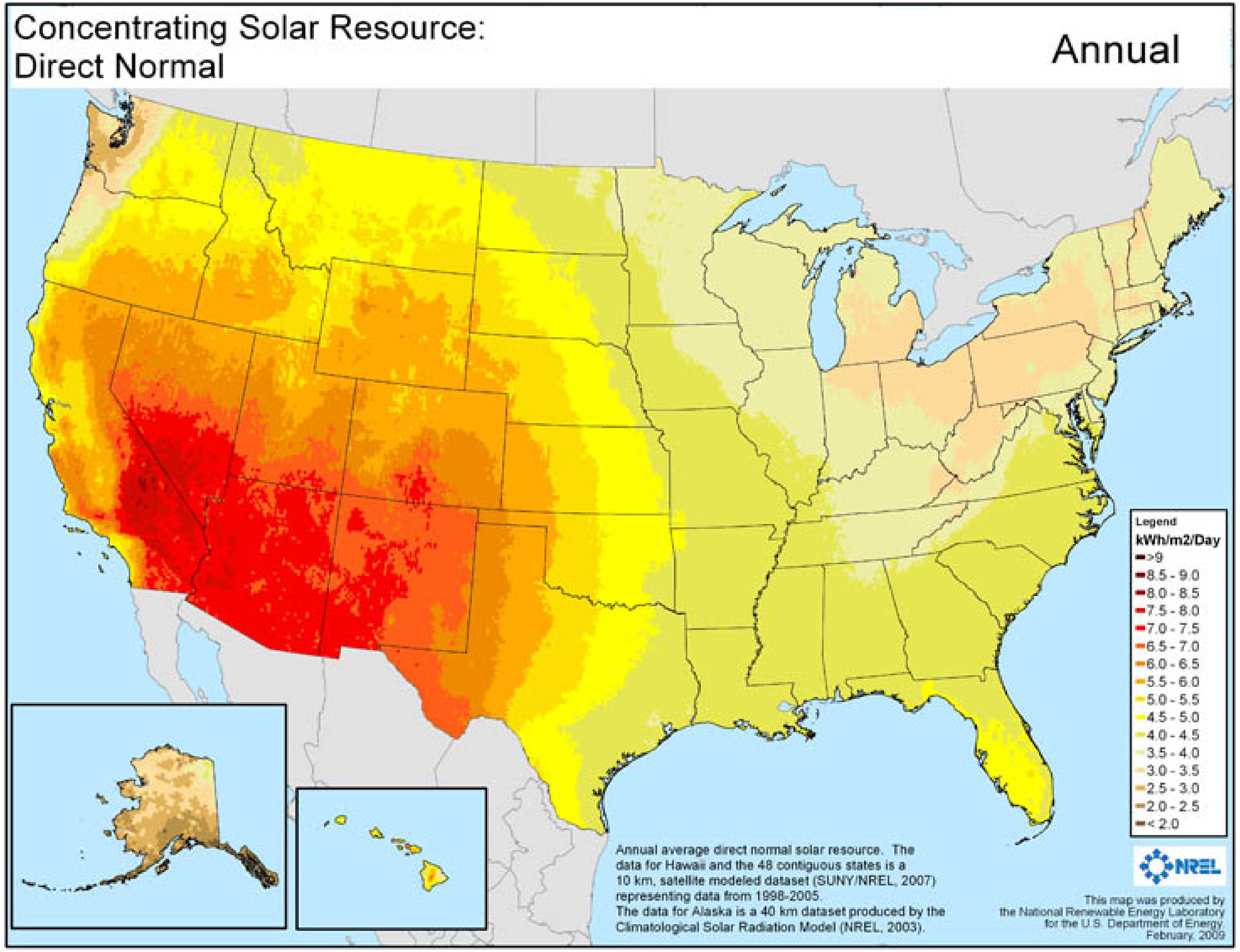
PV/Wind feasibility analysis

list of assumptions/renewable energy systems technology considerations



PV Solar Radiation:

This map provides monthly average and annual average daily total photovoltaic (PV) solar resource, averaged over surface cells of 0.1 degrees in both latitude and longitude, or about 10 km in size. This data was developed using the State University of New York/Albany satellite radiation model.



Concentrating Solar Power Radiation:

These maps provide monthly average and annual average daily total concentrating solar power (CSP) resource, averaged over surface cells of 0.1 degrees in both latitude and longitude, or about 10 km in size. This data was developed using the State University of New York/Albany satellite radiation model.

Advantages:

- Good Solar Insolation In Missouri (Average For Country)
- Lower Cost Per Kw Than Wind
- Can Be Visible Environmental Symbol

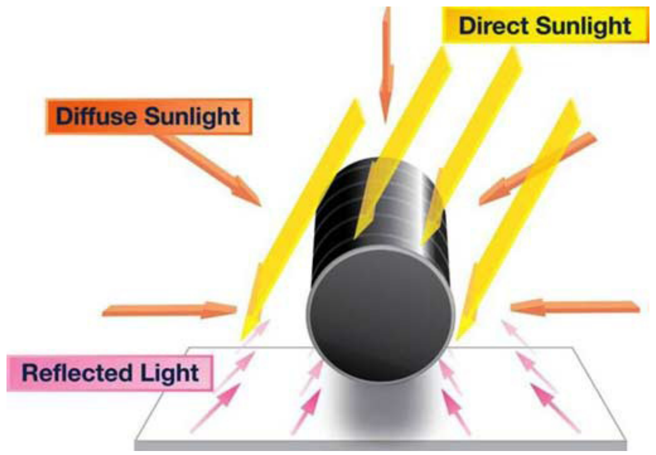
Disadvantages:

- Still Relatively High Cost
- Can Be Dramatically Effected By Partial Shading

Tilt-up Flat Plate Solar Panels

BIPV Thin Film Roof Membrane

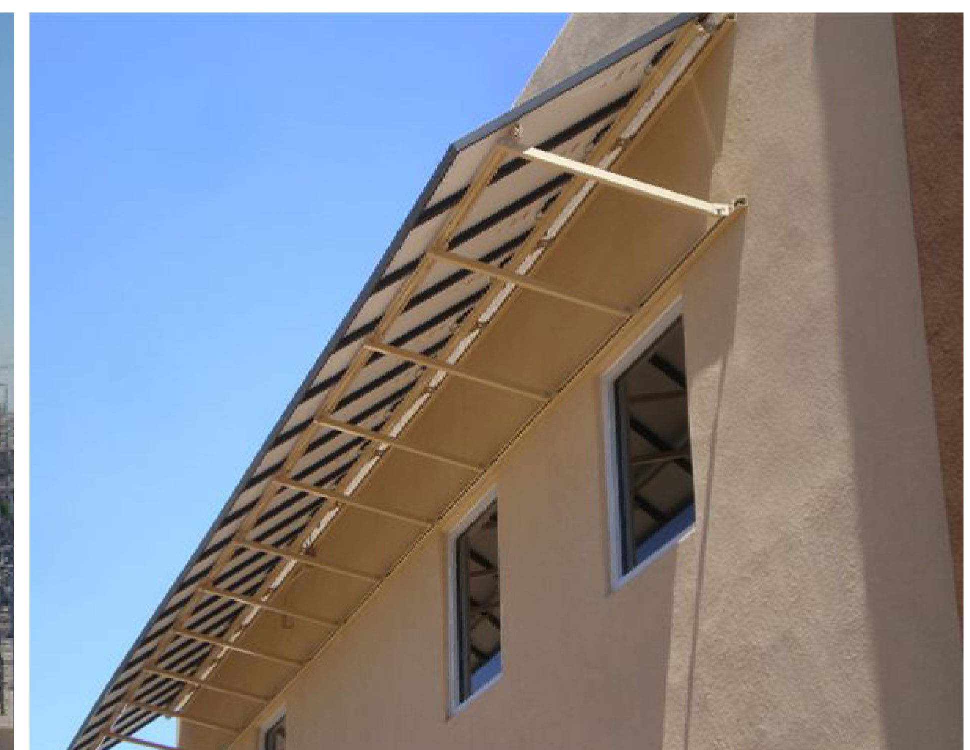
Building integrated photovoltaics are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades. The advantage of integrated photovoltaics over more common non-integrated systems is that the initial cost can be offset by reducing the amount spent on building materials and labor that would normally be used to construct the part of the building that the BIPV modules replace.

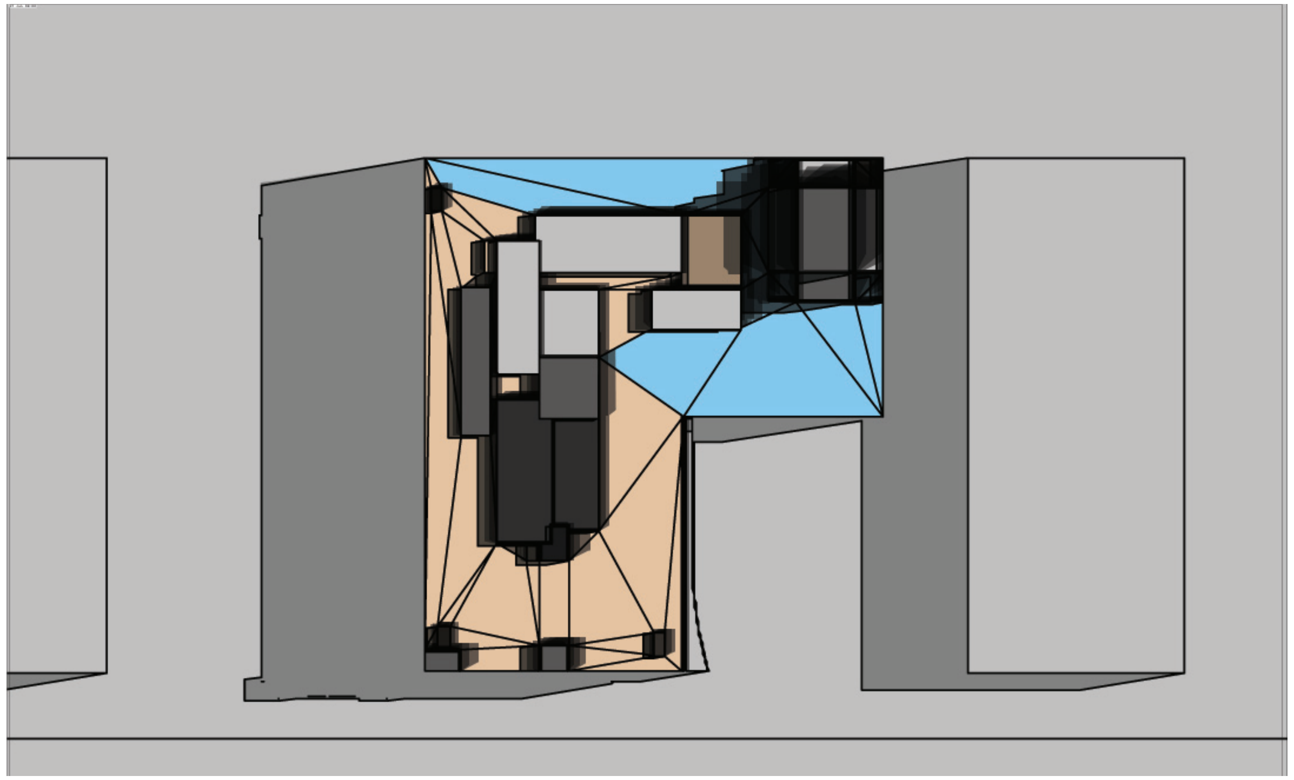


Tubular Photovoltaics

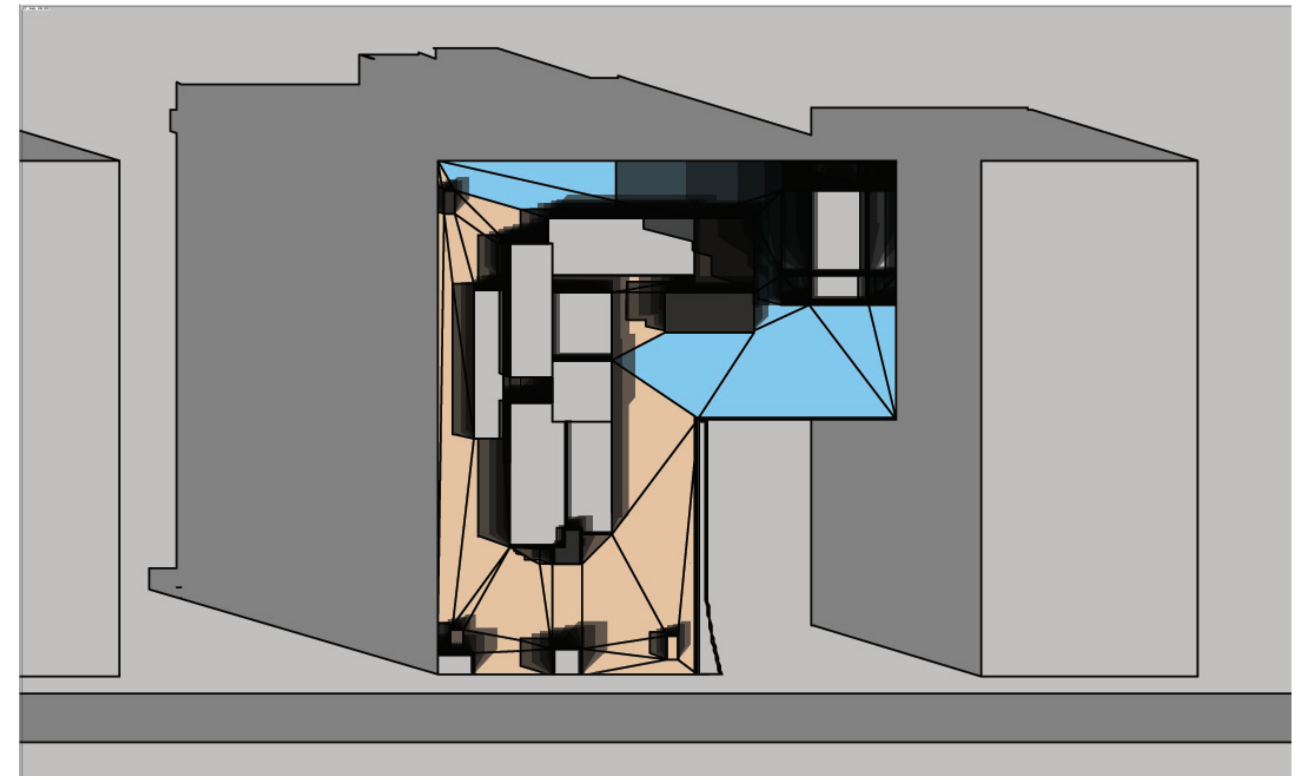
Conventional flat PV panels must be mounted at an angle and spaced apart for optimum energy production. The sunlight striking the spaces between the panels is not collected and therefore is wasted. Tubular PV panels perform optimally when mounted horizontally and packed closely together, thereby covering significantly more of the available roof area and producing more electricity per rooftop on an annual basis than a conventional panel installation.

PV Awning

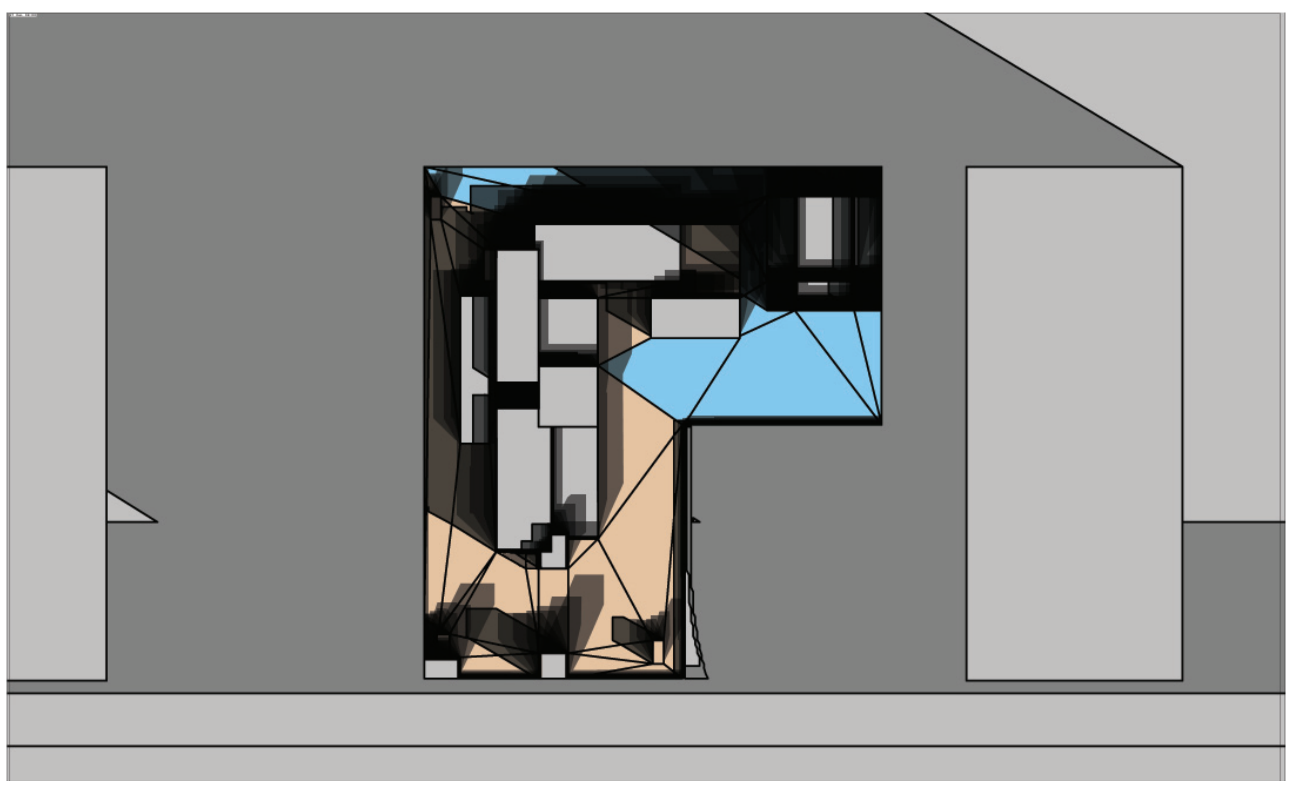




Summer 9am - 3pm



Spring/Fall 9am - 3pm



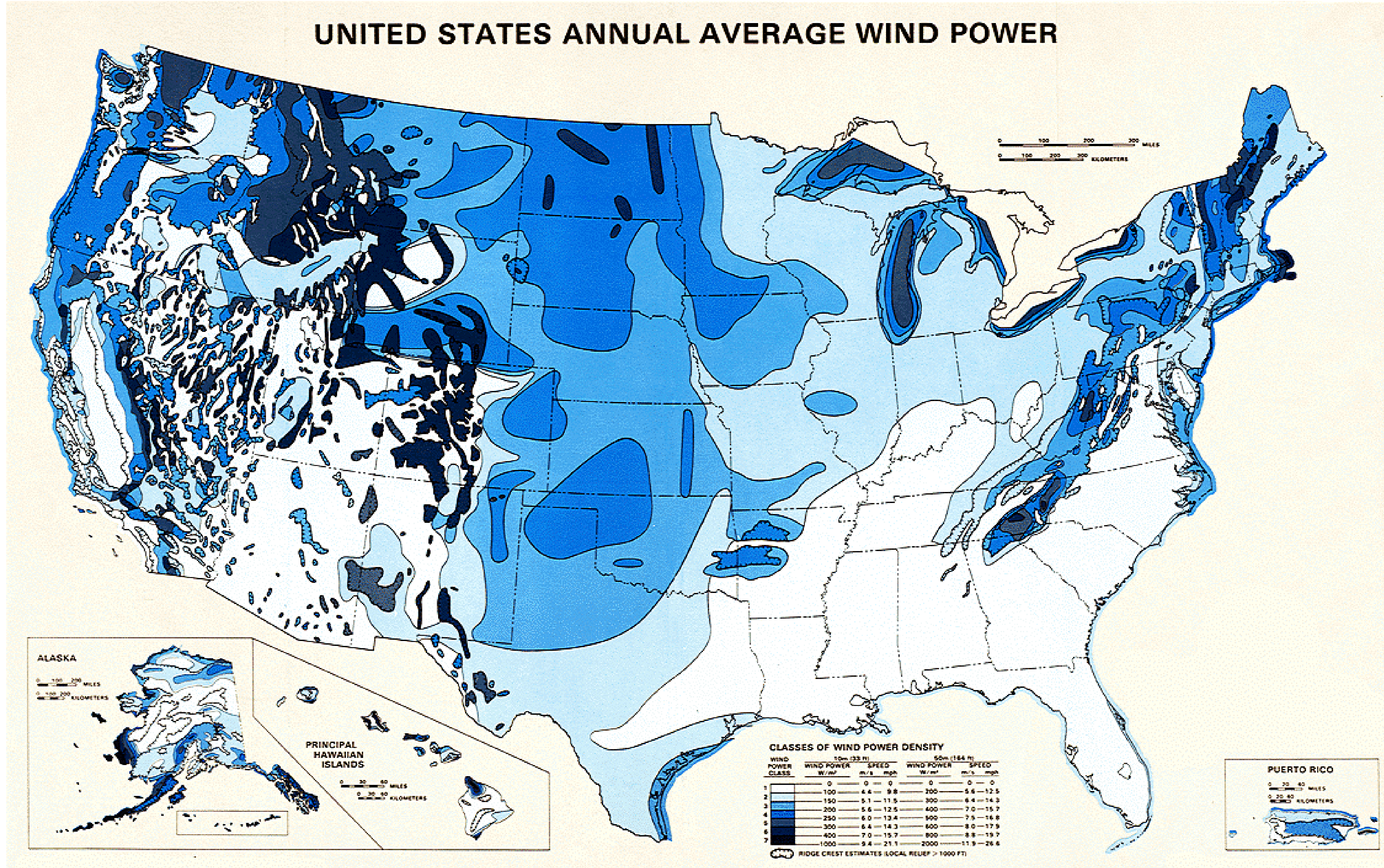
Winter 9am - 3pm

These shading diagrams show where the major masses cast shadows on the main roof. This helped define areas where the sun hit for a majority of the day.

US Annual Average Wind Power

Areas that are potentially suitable for wind energy applications (wind power class 3 and above) are dispersed throughout much of the United States.

Major areas of the United States that have a potentially suitable wind energy resource include: much of the Great Plains from northwestern Texas and eastern New Mexico northward to Montana, North Dakota, and western Minnesota; the Atlantic coast from North Carolina to Maine; the Pacific coast from Point Conception, California to Washington; the Texas Gulf coast; the Great Lakes; portions of Alaska, Hawaii, Puerto Rico, the Virgin Islands, and the Pacific Islands; exposed ridge crests and mountain summits throughout the Appalachians and the western United States; and specific wind corridors throughout the mountainous western states.

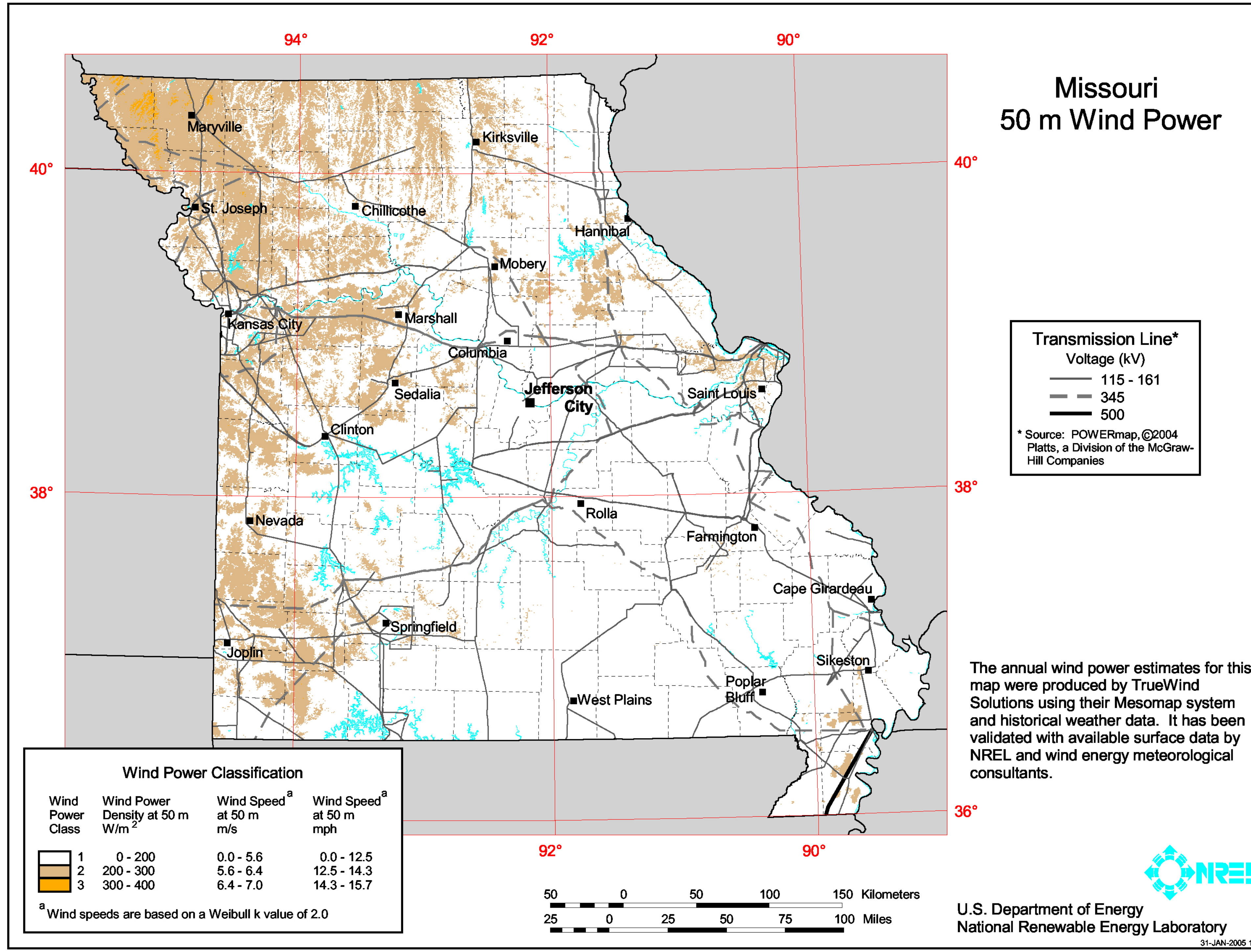


Missouri 50 meter map

This resource map shows wind speed estimates at 50 meters above the ground. Future plans are to provide wind speed estimates at 30 meters, which are useful for identifying small wind turbine opportunities.

As a renewable resource, wind is classified according to wind power classes, which are based on typical wind speeds. These classes range from class 1 (the lowest) to class 7 (the highest).

This map shows the highest wind resources in Missouri are found in the extreme northwestern part of the state. Class 3 areas are concentrated from St. Joseph north to the Iowa border. Particular locations in the Class 3 areas could have higher wind power class values at 80-m than shown on the 50-m map because of possible high wind shear. Given the advances in technology, a number of locations in the Class 3 areas may be suitable for utility-scale wind development.



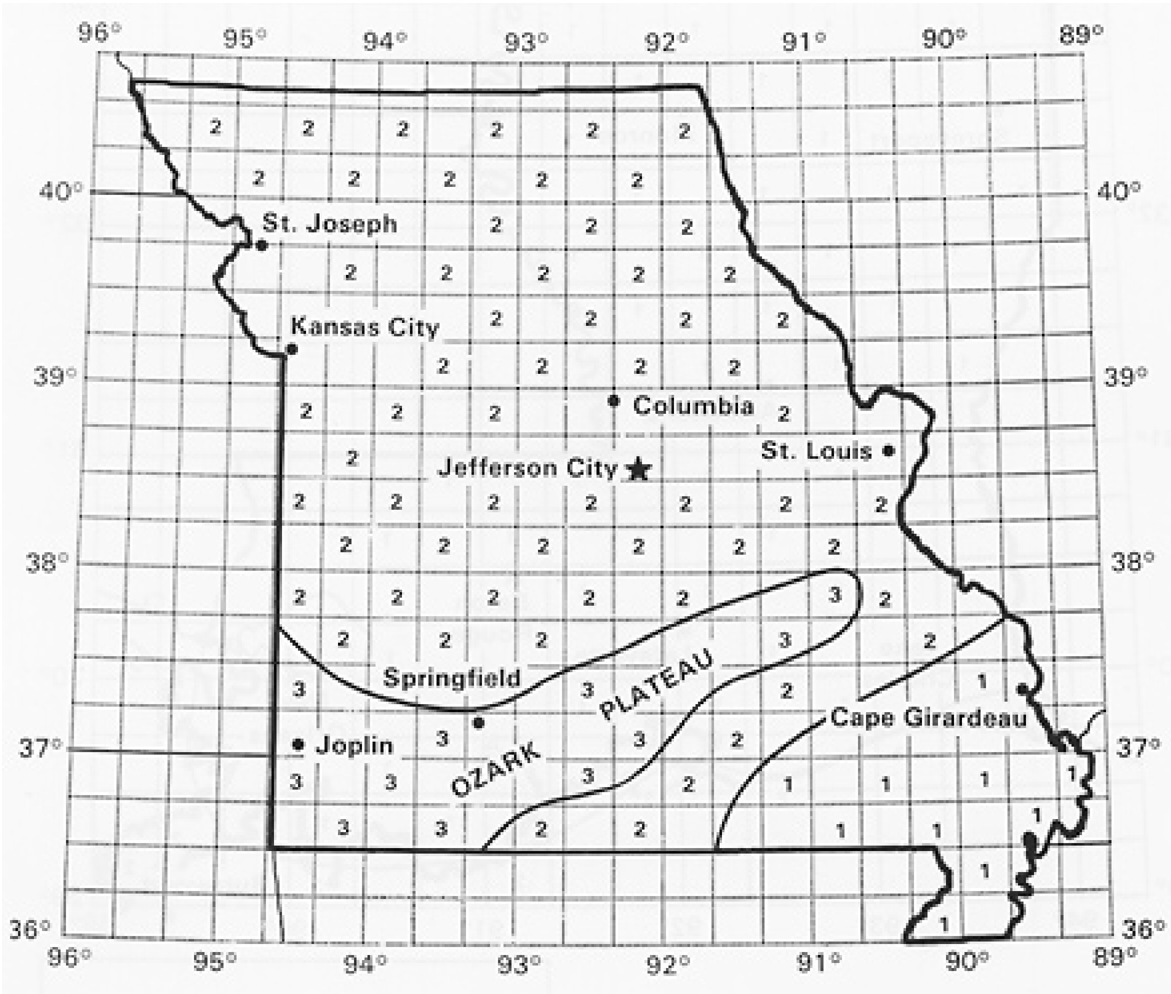
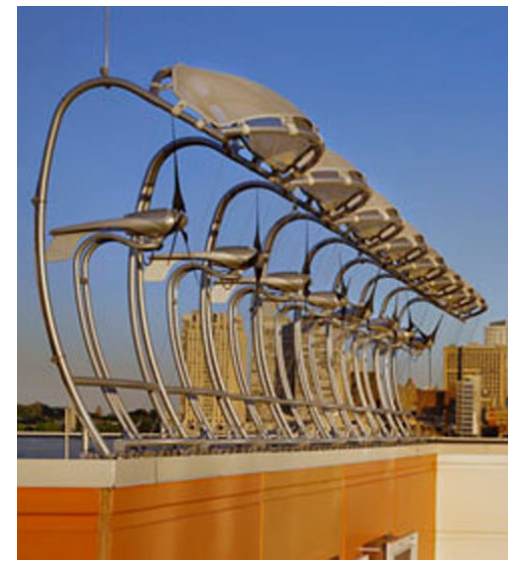


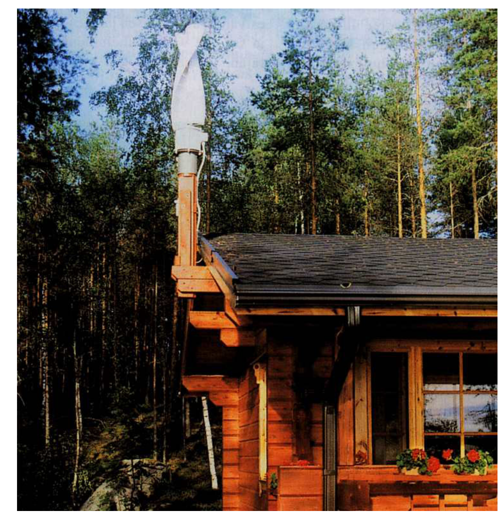
Table 1-1 Classes of wind power density at 10 m and 50 m(a)

Wind Power Class	10 m (33 ft)		50 m (164 ft)	
	Wind Power Density (W/m 2)	Speed (b) m/s (mph)	Wind Power Density (W/m 2)	Speed (b) m/s (mph)
1	0	0	0	
2	100	4.4 (9.8)	200	5.6 (12.5)
3	150	5.1 (11.5)	300	6.4 (14.3)
4	200	5.6 (12.5)	400	7.0 (15.7)
5	250	6.0 (13.4)	500	7.5 (16.8)
6	300	6.4 (14.3)	600	8.0 (17.9)
7	400	7.0 (15.7)	800	8.8 (19.7)
	1000	9.4 (21.1)	2000	11.9 (26.6)



Parapet mounted Wind Turbine

Unlike the common conception of the wind turbine, which often has blades up to 30 feet in length, Parapet mounted wind turbines are designed with a minimal footprint in mind. The entire turbine housing is around 7 feet tall by 6 feet wide and has mounting options for roofs with and without parapet walls, making it a perfect fit for on-site renewable energy generation. Turnkey costs can range from $6.00 to $8.00 per Watt installed, depending on system size and site.



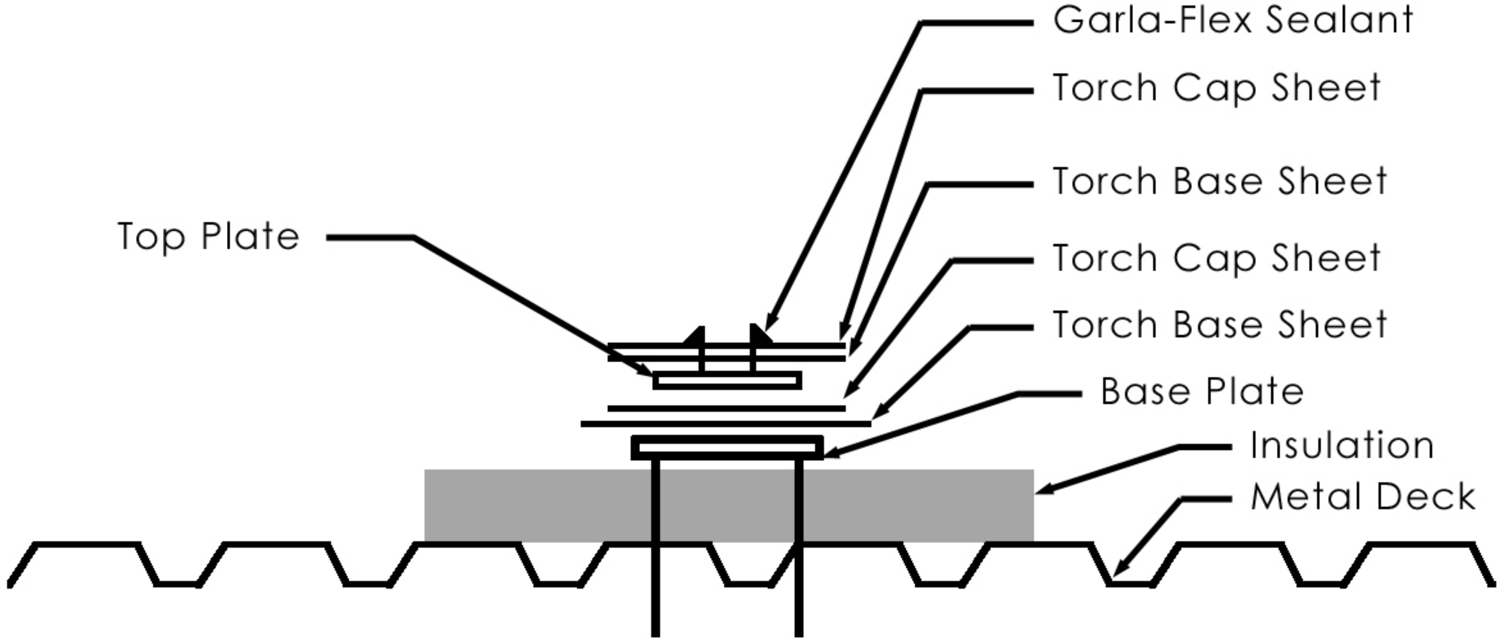
Vertical Axis Wind Turbine

Vertical Axis Wind Turbines have the main rotor shaft arranged vertically. Key advantages of this arrangement are that the turbine does not need to be pointed into the wind to be effective. This is an advantage on sites where the wind direction is highly variable.

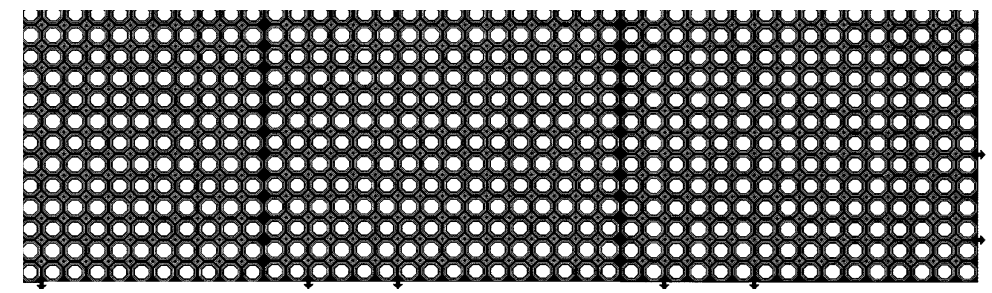
With a vertical axis, the generator and gearbox can be placed near the ground, so the tower doesn't need to support it, and it is more accessible for maintenance. Drawbacks are that some designs produce pulsating torque.

photo of tuckpointing with stage

Typical penetration details
copy of warranty



Typical PV Attachment Roof Penetration



Recycled Rubber Mat

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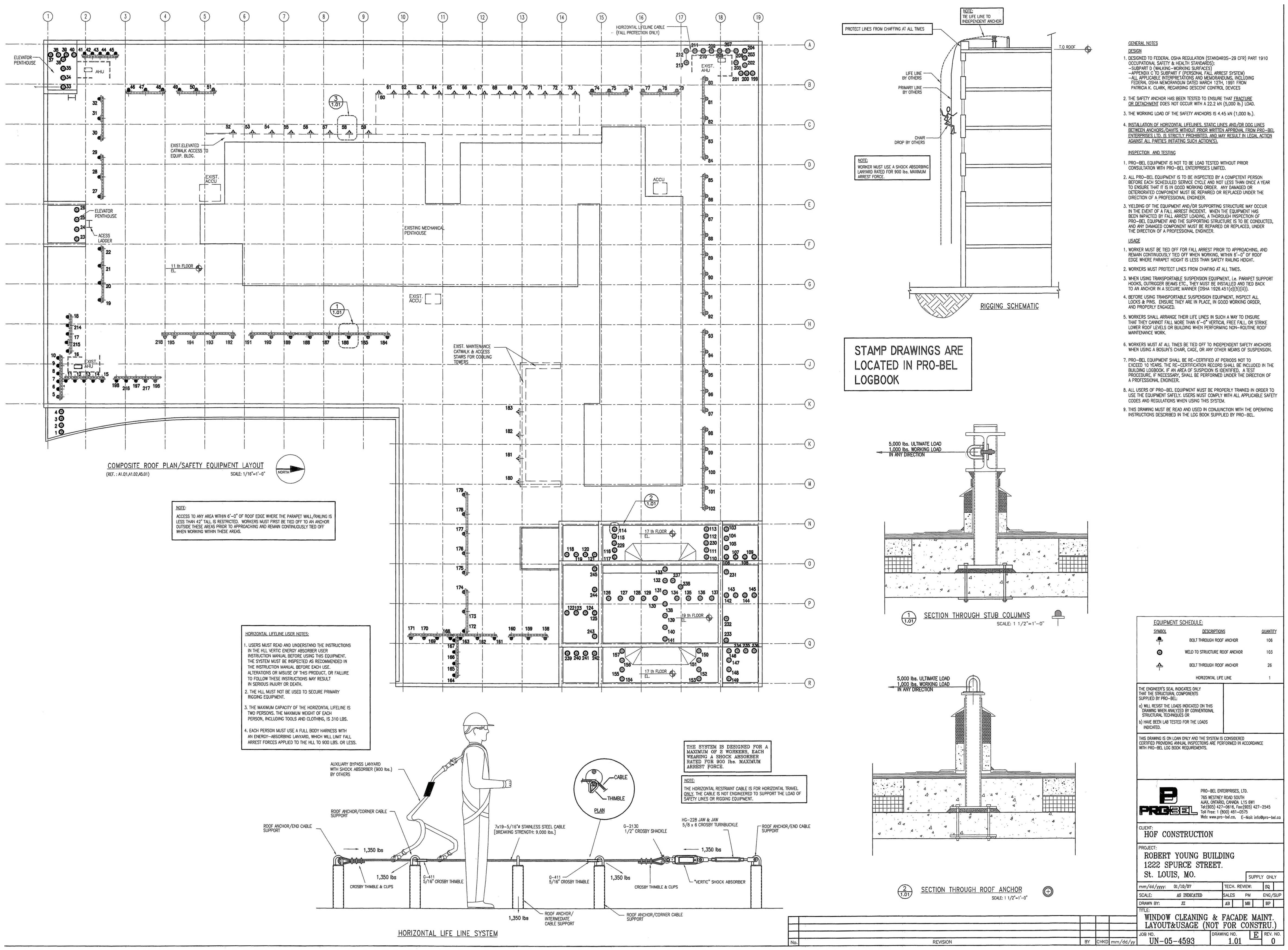
window washing infrastructure



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architects

WINDOW WASHING:

BUILDING MAINTENANCE CONTRACTOR

True Blue Building Maintenance
Brian Gerkins
1222 Spruce Street
#10.204
St. Louis, MO 63103-2822

WINDOW WASHING SUBCONTRACTOR

Hawkins Building Services
Steven Hawkins
11040 Lin Valle Drive
St. Louis, MO 63123-7210
Tel: 314-845-7000
Cell: 314-422-8920
Email: hbssl@aol.com

Direct Rigging (Direct-to-Safety-Anchor) safety anchors provide an effective, practical means for directly securing a bosun's chair equipped with a descent control device. The chair is rigged directly to wall or roof anchors in line with the point of suspension, and the primary synthetic rope suspension lines are normally protected at the roof edge using contractor supplied carpet or other anti-abrasion protection devices. Alternatively, contractor supplied equipment such as outrigger beams with counterweights, parapet wall clamps or cornice hooks can be used to suspend the chair. These devices must be tied back to permanently installed safety anchors. At present these are not used for window cleaning.

Window washing for all facades at the Robert A. Young Building is done using a Bosun's (Boatswain's) Chair utilizing the Probel Anchoring System recently installed on the roof.

Description
The descent controlled bosun's chair is one of the most common and popular
types of equipment employed for exterior building maintenance. The main advantage is that the chair is lightweight and simple to rig. Chairs are considered conventional equipment supplied by the window cleaning or other type contractor. A descent control device is primarily intended to allow downward movement only.

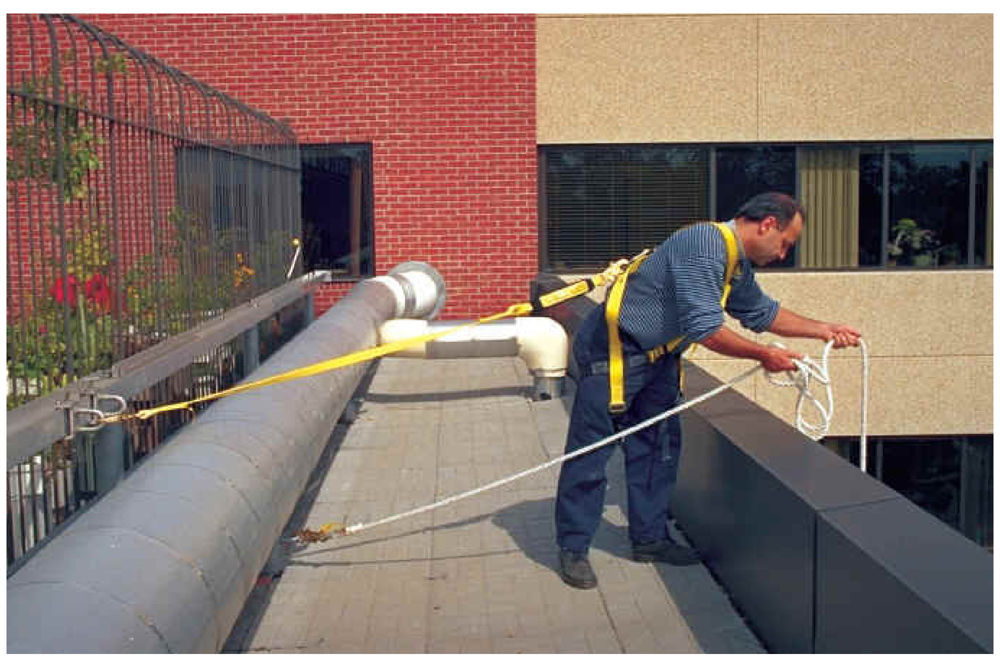
HORIZONTAL TROLLEY RAIL SYSTEMS

Description

When architectural building features require worker's lanyards, lifelines and primary equipment to move horizontally over an extended distance, single point anchors along an entire work zone may not be feasible or desirable. The solution is a fully engineered horizontal trolley rail lifeline system. A horizontal rail lifeline is a permanently installed, multi-span anchored rail which serves as an attachment point for lanyards, lifelines, direct rigging (attachment of primary suspension equipment), and for securing tie-back lines. Trolley rails differ from horizontal cable lifeline systems in that trolley rails are considered a non-restrictive, more heavy duty fall protection system whereas cable systems are highly restricted, lighter duty and subject to amplified loads. The RAY building has been outfitted with Steel Horizontal Trolley Rails.

For staging, the parapet wall must be strong enough to support applied loads of suspension ropes, wall clamps/hooks or outrigger beams with counterweights. Alternatively, a portable davit arm or outrigger beam dolly can be used to clear the parapet.* At present, only ropes are used for the Bosun's Chair. A davit arm or dolly is only used for tuckpointing when a stage is needed for more secured work on the façade.

* adapted from Probel's Window Cleaning/Suspended Maintenance



WINDOW CLEANING LOGISTICS AND PV PANEL PLACEMENT ISSUES

To facilitate the window washing process which occurs on a frequent basis, H+B recommends allocating a 6' aisle on the parapet side of the anchor to facilitate tie offs. A 10' aisle has been provided along the parapets on the lower roof to facilitate roof access and parapet access in general and staging the bosun's chair in particular. Aisles have also been provided between the anchor beam and the parapet. In the event of needing a davit outrigger, an aisle has also been provided parallel to the parapet for wheeling. The panel surface could be covered with a heavy tarp to avoid damage.

The tie-offs on the penthouse roofs on the south façade are never actually utilized however the anchors would still be functional as the wind turbine has a broad under frame that supports it.

On the south façade adjacent to Highway 64, where PV awnings have been proposed, H+B had a lengthy conversation with Steve Hawkins, whose crew actually does the window cleaning. He has concerns with using a bosun's chair too far away from the window surface and thinks that swinging in under the canopies is impractical and reaching to clean the window suface is also difficult to do properly. Using a stage is a possibility and as there are no panels proposed in this area a davit outrigger could be easily utilized. Steve prefers not to be over 3' away from the building surface which would require some adjustment on our most efficient proposed layout. He can also provide an estimate for cleaning this one façade.
Another solution would be to provide gaps between the groups of windows which would allow the bosun's chair to descent between them and even the group of three windows could be cleaned from both sides. This solution has to be balanced with the standard PV panel size related to window group width but is probably the best solution.

Net Metering/Interconnection

Net metering is a special metering and billing arrangement between a utility and customers who choose to install small renewable generation systems like wind turbines and photovoltaic (PV) panels and interconnect them to the utility. Net metering encourages the development of small-scale renewable energy systems by providing increased savings to customers. It also ensures that customers have a reliable source of energy from their utility during times when their renewable generators are not producing energy.

Net metering refers to billing practices that allow energy charges to be assessed by a utility based upon the difference between how much energy the customer-generator takes from the utility and how much it delivers to the utility over the entire billing period. This is sometimes called "letting the meter spin backwards." Net metering allows a customer-generator to "store" excess generation with the utility for use at a later time, or to replace energy previously "borrowed" from the utility. This service is offered without incurring any additional charges from the utility for that service. These systems encourage diversification of the current energy portfolio and help lessen the environmental footprint associated with electrical generation and consumption. In addition, customers with net metering systems tend to be much more aware of their energy consumption, so they usually consume less energy than the average retail customer. Net metering can also help increase the energy in the power grid, which helps the utility keep up with increases in demand during peak power-use times.

Missouri law prohibits a customer from operating a generator tied to the utility without the utility's prior approval. It is in everyone's interest to ensure that a customer's generator and the utility system work together in a safe and reliable manner. "Interconnection" is the process of sharing information with and receiving approval from the utility before the generator begins operating.

INTERCONNECTION APPLICATION/AGREEMENT FOR GENERATOR SYSTEMS WITH CAPACITY OF 100 kW OR LESS (NO NET METERING)

*** For Customers Applying for Interconnection:**

If you are interested in applying for interconnection to the electrical system of Union Electric Company d/b/a AmerenUE (Company), you should first contact Company and ask for information related to interconnection of parallel generation equipment to Company's system and you should understand this information before proceeding with this Application. If you wish to apply for interconnection to Company's electrical system, please complete sections A, B, C, and D, and attach complete plans, specifications, schematics and wiring diagrams describing the parallel generation and interconnection facilities (hereinafter collectively referred to as the "Generator System") and submit them to Company at:

One Ameren Plaza
1901 Chouteau Avenue
St. Louis MO 63103
Att: Manager Regulatory

You will be provided with an approval or denial of this Application. Company will provide notice of approval or denial within thirty (30) days of receipt by Company for Generator Systems of 10 kW or less and within ninety (90) days of receipt by Company for Generator Systems greater than 10 kW. If this Application is denied, you will be provided with the reason(s) for the denial. If this Application is approved and signed by both you and Company, it shall become a binding contract and shall govern your relationship with Company.

*** For Customers Who Have Received Approval of Generator System Plans and Specifications:**

After receiving approval of your Application, it will be necessary to construct the Generator System in compliance with the plans and specifications described in the Application, complete sections E and F of this Application, and forward this Application to Company for review and completion of section G at:

One Ameren Plaza
1901 Chouteau Avenue
St. Louis MO 63103
Att: Manager Regulatory

Company will complete the utility portion of section G and, upon receipt of a completed Application/Agreement form and payment of any applicable fees, permit interconnection of the Generator System to Company's electrical system. Customer will have one (1) year from the time of Company's approval to complete the interconnection after which time, the approval shall expire and the Customer shall be responsible for filing a new application.

*** For Customers Who Are Assuming Ownership or Operational Control of an Existing Generator System:**

If no changes are being made to the existing Generator System, complete sections A, D and F of this Application/Agreement and forward to Company at:

One Ameren Plaza
1901 Chouteau Avenue
St. Louis MO 63103
Att: Manager Regulatory

Interconnection Requirements for Metering an Electric System of 100 kW or Less :

The following is required for interconnection of a photovoltaic (PV) or wind power source in parallel with the Ameren distribution system:

• Ameren must review the project, before operation, to determine whether the PV or wind system could adversely affect the safety, reliability or quality of local electric utility service.

1. Ameren engineers will perform an Interconnection Study (at owners expense) to review the project. The system must include all necessary equip ment to properly protect Ameren's employees and other customers from any disruption or hazardous condition that could be caused by the PV or wind system. Requirements can vary depending on the size, type and location of the PV or wind system.

2. A Parallel Operating Agreement must be executed. This is a contract between the owner and Ameren that authorizes the owner to operate the PV or wind system in parallel with the Ameen system.

3. A Missouri licensed electrician or Missouri licensed engineer must inspect and sign your agreement with Ameren stating the customer-generator system satisfies all requirements in Section C - Quality of Service of the agreement.

4. Once the system is installed, Ameren may conduct a final inspection before allowing parallel operation of the PV or wind system.

• The PV or wind system must comply with all applicable codes, laws and regulations.

• The PV or wind system must be capable of automatically disconnecting from the company system. During an outage on the utility system, an inter connected PV or wind system can back-feed an Ameren line, creating a hazardous condition for utility workers and others. To prevent backfeed, the PV or wind system must either automatically disconnect from or cease to energize Ameren electric lines when a loss of the utility company's supply oc curs. The PV or wind system must be installed in accordance with current IEEE standards and be UL-listed.

• Non-islanding inverters are required.

• For PV or wind systems greater than 10kW output, operating and instruction manuals for the specific model of equipment being installed must be submitted to Ameren for review prior to connection of the equipment.

• The system must include a manual visible AC disconnect, located near the electric meter, that is accessible to Ameren staff and lockable with Ame ren locks. This allows Ameren crews to disconnect the PV or wind system from the utility company system for maintenance, reliability and safety con cerns.

• The system must include appropriate wiring and metering to sell excess electricity from the PV or wind system back to the Ameren system. It is strong ly recommended that the details of the project be discussed with Ameren personnel at the earliest possible time and investigation of all state and federal agency requirements is performed prior to proceeding.

Recommendation

If the amount of energy to be generated by the proposed wind turbine and photovoltaic systems for this project is anticipated to be 200 kW or less, this energy would be consumed entirely by the building systems and there would never be an excess to feed back to the utility. Therefore, a parallel operating agreement will be required with Ameren in lieu of the net metering option. The installation must still conform with Ameren guidelines and will still require Ameren's review and approval.

Robert A. Young Building kWh

KWH Summary 10/5/2009

Meter Number	2007	2008	2009	TOTAL
2838109	8,625,346	8,346,214	7,318,833	24,290,393
2838158	12,149,272	12,609,468	9,553,891	34,312,631
56836763	353	366	302	1,021
TOTAL	20,774,971	20,956,048	16,873,026	58,604,045

cooler evaporation water settlement
access requirements to equipment

Photovoltaic (PV) Solar Panels:

Currently there are three types of PV systems that are being considered. All of the systems being considered are relatively lightweight systems. A roofing membrane system is being considered for the majority of the PV panels on the roof. These panels consist of Monocrystalline Silicon cells. This type of system would be used on the penthouse roof area over the Air Handling Units and on the main roof in areas that are subject to coordination with window washing equipment and tie-backs. The panels would be installed flat and weigh approximately 2 lbs. per sq. ft. At such a low weight, it may be possible to install these PV cells directly over the AHU's without reinforcing the roof of the existing units.

The other two PV panel types being considered are more efficient. Only one of the two systems being considered will be used for the remainder of the areas receiving PV cells. One type is a highly efficient panel utilizing Cylindrical CIGS cells manufactured by Solyndra. The other panel type being considered is a Poly-crystalline Cell that would be installed on a rack system at a 10 degree tilt. The addition of ballast and the rack make it the heaviest of the systems being considered. However, with the rack systems being considered, attachments can be made through the roofing membrane directly to the structure below thereby reducing the amount of ballast required.

The PV array panels will be loaded by both wind and snow and have been tested for loads in excess of those prescribed by the building code. Manufacturer's literature stating the net load increase to the roof is as little as 2 to 3 lbs. per sq. ft. will require further research and verification. Snow accumulation will depend upon the PV panel configuration. Snow drifting loads will not be a consideration for panels installed flat or nearly flat.

Evergreen Flat Plate Panels

Applied Solar BIPV Membrane

Solyndra Tubular Panels

Vertical Axis Wind Turbines (VAWT):

Vertical wind turbines are being considered as a potential source of energy from wind at the RAY Building. The wind turbines being considered are 712V Aeroturbines. These vertical axis wind turbines are surrounded by a structural cage that provides rigid support at the bottom and top of the airfoils. This type of design makes the turbine less susceptible to vibrations. The structural cage also spreads out at the base covering a roof area of approximately 87 sq. ft. This wider base is more stable and helps reduce the reactions at the corners of the frame. The frame can be anchored directly to the structure below at four support points requiring penetration of the roofing membrane, or it can be installed with a ballast system. The overall weight of an unballasted system is less than 1000 lbs. with an average weight of approximately 10 lbs. per sq. ft, however it requires connections through the roof membrane. A ballasted system will average 18 lbs. per sq. ft. on the existing roof and eliminates the need for roof penetrations.

Roof Reinforcement for new loads

The weight of photovoltaic panels varies depending on the manufacturer and the type of system being considered. The weights of PV systems being considered for this project will vary from 2 to 5 lbs. per sq. ft. for unballasted systems. The exception to this is the poly-crystalline cell array installed on a rack system at a 10 degree tilt. This system will require additional ballast to resist uplift forces due to wind. However, by anchoring the rack system to the building structure, the amount of ballast required can be reduced to keep the total weight of the system within the capacity of the roof system on which it is being installed. Loads of these magnitudes are a small percentage of the total roof live and dead load and can probably be shown to be acceptable. Based on engineering judgement and generally accepted practice it is usually acceptable to allow increases in loads up to about 5% of the total existing load.

The weights and capacities of the various structural systems of the existing roofs are wide ranging. The main roof at the 11th floor roof level is a 6-1/4" concrete slab. As previously noted there are no reinforcing schedules in the available drawings and the existing capacity of the roof could not be calculated. The total weight of the roof system including dead and live loads is approximately 125 lbs. per sq. ft. Therefore an increase of 6 lbs. per sq. ft. or less will be within the acceptable load increase range. At the penthouse roofs framed with steel joists and metal deck, the capacity of the roofs have been calculated to average 20 lbs. per sq. ft. dead load with available live load capacities ranging from 20 to 30 lbs. per sq. ft. for an allowable total load of 40 to 50 lbs. per sq. ft. Systems that weigh 2 lbs. per sq. ft. or less may be acceptable without additional structural reinforcing. The roof structure of the existing AHU's is unknown at this time. We have assumed they can accept an additional load of only 2 lbs. per sq. ft., therefore, it may be possible to add PV cells on the AHU roofs without reinforcing. As a fallback position, a thin film system adhered to the metal roof panels and weighing only about 1 lb. per sq. ft. could be substituted here, but this type system would have a reduced efficiency. Alternatively, the AHU roof could be over-framed with a structural frame to support the PV arrays at a cost of approximately $15 per square foot. This scenario could add as much as $195,000 to the project. Finally, the existing penthouses along the southern edge where the Vertical Axis Wind Turbines are proposed has an existing dead load of approximately 70 lbs. per sq. ft. with an allowable live load capacity of 40 lbs. per sq. ft. While this live load capacity may be adequate to support a ballasted VAWT installation, it is preferred that the turbines will receive a structural connection through the roof membrane at the four corners.

Although individual components and connections of systems being added at the roof must be designed for seismic loads, the existing building will not need to be analyzed or reinforced for a seismic upgrade. It can easily be shown that the amount of load being added at the roof will not exceed the 5% threshold that would trigger a seismic analysis and upgrade to the structure.

Most of the products being considered for this study have published manufacturer's literature that will indicate additional connections to the structure are not required. Photovoltaic system manufacturers will also note that no additional reinforcing of the structure is required due to the extremely light weight of the system. They also make the claim that the PV cells will stand up to wind loads equal to or greater than the prescribed wind loads for this region. The gravity loads and upward or downward wind loads provided in their literature may in fact be based on idealized conditions that may not exist at this project site and the loads/conditions will have to be vetted prior to acceptance. All of these statements will have to be verified and ultimately substantiated by the manufacturer by submitting calculations and test data.

Wind on the panels supported by a rack system will create significant reactions at support points. Rack systems typically provide continuous support at the panel edges. Ballasted systems that weigh more than about 5 lbs. per sq. ft. can have their average weight reduced by providing additional attachments to resist uplift. The upward and downward forces at these support points might be as large as 3000 pounds. Installing ballast to offset the uplift for this magnitude of loading (which would be preferable from a protection of the roof membrane standpoint) might require major roof reinforcement. Concrete anchors or through bolts could easily be designed for loads of this magnitude.

Where the PV panels on a rack system are located on the penthouse roofs, reinforcement of the steel joist framing will be required at each support point. The structural reinforcement cost of installing these panels over large areas of the penthouse roof would be $1,500 per support location in addition to the connection of the rack system to the structure to resist uplift. The total cost of a connection at the Penthouse Roof is approximately $2500 per connection.

The wind turbine described above would have an insignificant weight but in high winds would impose over-turning forces on the supporting roof. It is being proposed to install the vertical axis turbines on the two penthouses on the southern edge of the building that were constructed as part of the 1942 addition. For the concrete joist slab roof over these penthouses, bolting through the slab and attaching to the joist structure below is an option. The wide base on the VAWT will spread the concentrated loads out to the corners of an area approximately 9 feet square. Concentrated loads at the corners would be approximately 2500 pounds. This force can be resisted by bolting through the slab and attaching to the joist structure below. The cost of reinforcing thru roof at each of these turbines would be about $2000 per connection or $8000 per turbine.

Structural costs associated with reinforcing the roof structure are summarized in the table below.

ESTIMATE OF PROBABLE STRUCTURAL COSTS		
Photovoltaic Cell Array Structural Costs		
	Area	Cost
Evergreen Panel System or Cylindrical Cell System. Main Roof	3140 sq. ft.	$22,000.00
Evergreen Panel System or Cylindrical Cell System. Penthouse Roof	2950 sq. ft.	$67,500.00
Applied Solar Panels All Roofs	13350 sq. ft.	$76,500.00
Over-framing At AHU's (If Required)	13000 sq. ft.	$195,000.00
Vertical Axis Wind Turbine Structural Costs		
	Quantity	Cost
712V Aeroturbine	3	$24,000.00

Section 3

PV/Wind concept layouts and payback analysis

PV/Wind concept layout

Lower Roof

Perimeter
Access to the perimeter is required for parapet maintenance as well as for staging of the window washing equipment for accessing the bosun's chair.

Code requires a 6' setback for installation and maintenance without having a guard rail but by tying off this is no longer required other than for the general access noted above. It is still recommended to leave a reasonable setback for general access as well as for parapet shading.

Window Washing System Access
Access to the tie-on side of the trolley beam along with perpendicular access at intervals from the trolley beam to the building perimeter is recommended to allow access for tying off of the Bosun's Chair.

In the event that an outrigger is utilized for the window washing infrastructure or occasional tuckpointing, an area of open roof can be provided for the wheel area parallel to the parapet wall and possible additional ballasting weights.

AHU Access

For maintenance, recommend leaving 3'-6' feet around the roof mounted AHU units. Due to misting and discharge, it may be necessary to clean the PV modules nearest the chillers on the south side of the easternmost roof section more often.

Structural Issues:
Due to low capacity for additional dead load on the lower roof slab, a lower weight, self-ballasting system or adhered system has been recommended for the less desirable sections of this roof. For the most open sections of the easternmost roof, a higher efficient system is recommended due to the high quality solar access. These types of systems are either ballasted with limited roof penetrations or self-ballasting but weigh more than the BIPV system.

Small Penthouse Roofs
Given their smaller footprints, structural system and higher elevation, these are good candidates for a Vertical Axis Wind Turbine application. One VAWT is proposed for each of these three roofs for a total of three (3).

As the underside of these penthouses is accessible, the structure can be strengthened if required to sustain the additional loading.

Any through roof anchoring will have to comply with Garland's Roof Warranty. (see roof penetration detail for rack and frame anchoring). It is recommended that especially over the main lower roof area that roof penetrations be kept to a minimum.

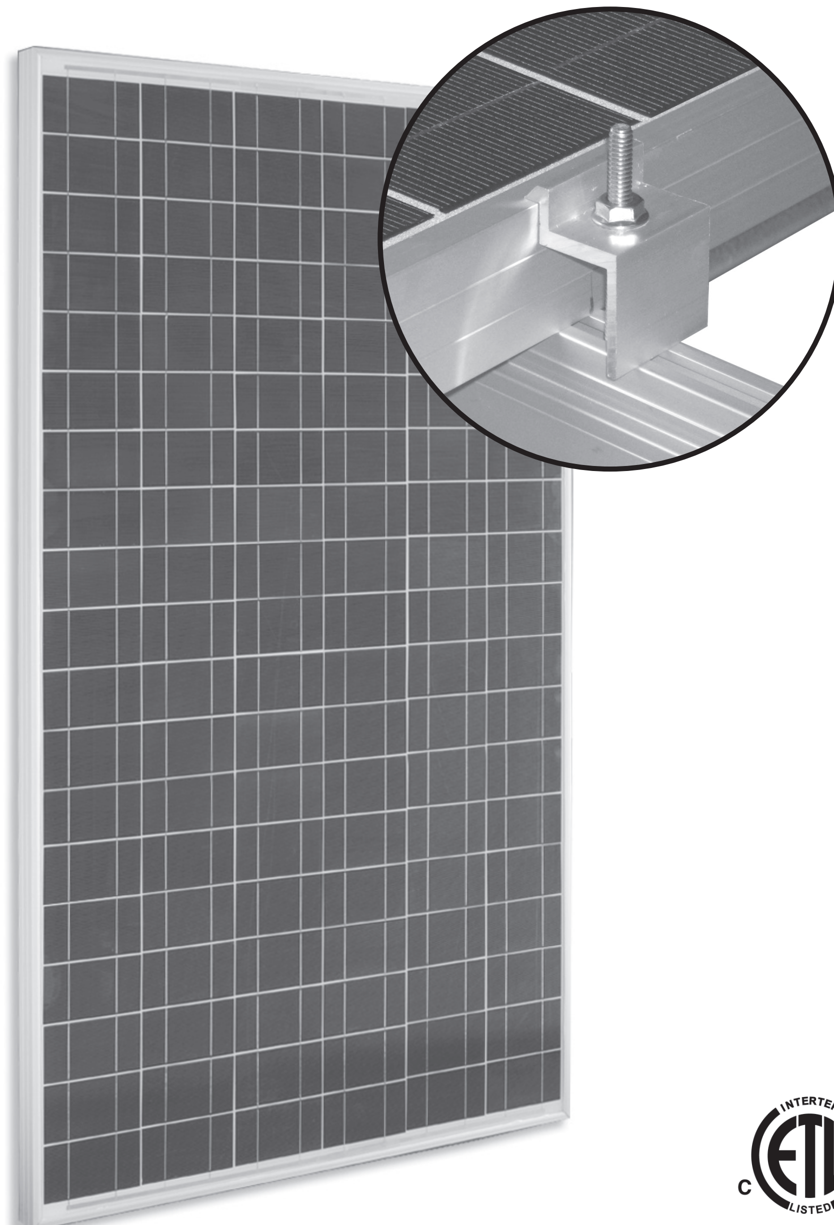
Due to the state of the art technology with the PV and Wind Systems that have been considered, H+B recommends a more thorough investigation into product claims, performance claims and visiting installed sites and speaking with the respective facility managers. Some of the companies considered have only recently set up dealer networks and are not prepared to answer detailed technical questions in any timely manner. There has also been some fall-out in the PV industry with products that do not meet expectations in the field. This is also why we have looked at different options and approaches responding to the complex existing conditions on the roof areas.

Options:

evergreensolar

ES-A Series Photovoltaic Panels

Mounting Guide

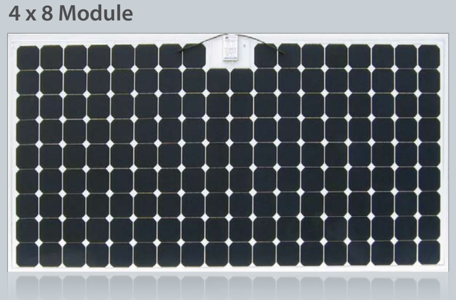


This Guide is valid in North America only
(ETL listed; conforms to UL Standard 1703)

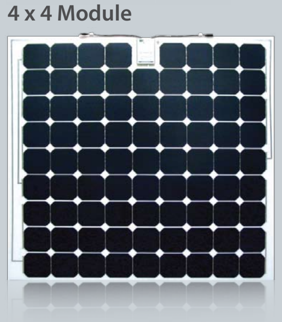
Applied Solar Roofing Membrane

Quiet And Reliable Power Generation

4 x 8 Module



4 x 4 Module



Applied Solar's BIPV Roofing Membrane is a unique product that maintains the natural look of your property while generating clean, safe, efficient electricity from the sun. The Solar BIPV Roofing Membrane product line is designed for commercial flat to lowslope roofs, integrating photovoltaic modules with single-ply roofing membranes.

(Continued on next page)

Applied Solar
Solar Energy for Every Rooftop™

877- APPLSOL (877-277-5765) | inquires@appliedsolar.com | www.appliedsolar.com

Applied Solar Roofing Membrane

At-A-Glance

BENEFITS

- Reduces pollution and green house gas emissions
- Significantly reduces or eliminates monthly energy bill
- Provides a safe and secure sustainable energy solution
- Bank your extra power with the local utility
- A maintenance free, state-of-the-art system
- Add significant resale value to the property
- Maintains natural look and aesthetic appeal of the property

FEATURES

- High efficiency crystaline silicon PV cells
- A completely waterproof solar roof with no penetrations
- Class A fire rated, UV stabilized and low maintenance system
- Hail resistant, low profile, wind resistant design
- Wind load rated up to 125 mph
- Maximizes energy output by installing around roof obstructions

INSTALLATION

- 20-year warranty covers roof material and energy performance
- Installs over existing roofs, no demolition and disposal costs
- Light weight, easy and inexpensive to install
- No structural reinforcement of the roof typically required
- No complicated rack mounting hardware required
- Modular, fully scalable and expandable
- Approximately 2 lbs. per sq. ft. installed
- Approximately 10 watts per sq. ft. installed

WARRANTY

- 20-Year Warranty On 80% Power Output

CERTIFICATIONS

- Class A Fire Rated
- CSA certified to UL 1703
- 600 VDC
- FSEC Listed

877- APPLSOL (877-277-5765) | inquires@appliedsolar.com | www.appliedsolar.com

TECHNICAL SPECIFICATIONS

Model	STP 400
Technology	Building-integrated Photovoltaic (BIPV)
Type of solar cell	Monocrystalline Silicon
Roofing applications	Commercial/residential, flat to a low slope; Maximum pitch of 2.5:12
Size of active solar area	48inx96in; 122cmx244cm
Membrane weight (active solar area)	20.9 kg 46 lb
Cell configuration	160 cells (2 parallel strings of 80 cells in series
Thickness of membrane	8mm
Thickness of junction box	23mm
Total thickness of membrane + JB	31mm
Connector type	Tyco Integral Connector
Bypass diodes	Laminated; 4 embedded diodes
Warranty	20-Year on 80% Power Output
Certifications (approvals pending)	Class A fire rated, CSA certified to UL 1703, IEC61215, 1000VDC
Voc	49.2
Isc	10.4
Vmp	41.5
Imp	9.6
Pmax	400

Model	STP 200
Technology	Building-integrated Photovoltaic (BIPV)
Type of solar cell	Monocrystalline Silicon
Roofing applications	Commercial/residential, flat to a low slope; Maximum pitch of 2.5:12
Size of active solar area	48inx48in; 122cmx122cm
Membrane weight (active solar area)	10.5 kg 23 lb
Cell configuration	80 cells (1 series string)
Thickness of membrane	8mm
Thickness of junction box	23mm
Total thickness of membrane + JB	31mm
Connector type	Tyco Integral Connector
Bypass diodes	Laminated; 5 embedded diodes
Warranty	20-Year on 80% Power Output
Certifications (approvals pending)	Class A fire rated, CSA certified to UL 1703, IEC61215, 1000VDC
Voc	49.2
Isc	5.2
Vmp	41.5
Imp	4.8
Pmax	200

Applied Solar
Solar Energy for Every Rooftop™

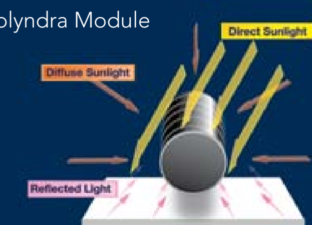
PV/Wind recommended systems

SOLYNDRA™
The new shape of solar™

Solar photovoltaic systems comprised of panels and mounting hardware for low slope, commercial rooftops.

Proprietary cylindrical modules optimize the collection of sunlight and enable Solyndra panels to achieve the highest rooftop coverage without the need for costly mounting hardware or rooftop penetrations. By significantly reducing installation costs and increasing the electricity generated per rooftop, Solyndra delivers electricity at the lowest cost per kilowatt hour.

Solyndra Module



Significantly more solar electricity per rooftop per year
Approximately 2x the roof coverage with no need for tilting and spacing

Fast, easy, economical installation
Typically, 1/3 the labor, 1/3 the time, at 1/2 the cost

Lightweight and self-ballasting
No penetrations or attachments required

Product Specifications

Electrical Data

Measured at Standard Test Conditions (STC) irradiance of 1000 W/m², air mass 1.5, and cell temperature 25° C

Model Number		SL-001-150	SL-001-157	SL-001-165	SL-001-173	SL-001-182	SL-001-191	SL-001-200 Release Date TBD
PowerRating (P_{mp})	Wp	150 Wp	157 Wp	165 Wp	173 Wp	182 Wp	191 Wp	200 Wp
Power Tolerance (%)	%/Wp	+4, -5	+/-4	+/-4	+/-4	+/-4	+/-4	+/-4
V_{mp} (Voltage at Maximum Power)	Volts	65.7 V	67.5 V	69.6 V	71.7 V	73.9 V	76.1 V	78.3 V
I_{mp} (Current at Maximum Power)	Amps	2.28 A	2.33 A	2.37 A	2.41 A	2.46 A	2.51 A	2.55 A
V_{oc} (Open Circuit Voltage)	Volts	91.4 V	92.5 V	93.9 V	95.2 V	96.7 V	98.2 V	99.7 V
I_{sc} (Short Ciruit Current)	Amps	2.72 A	2.73 A	2.74 A	2.75 A	2.76 A	2.77 A	2.78 A
Temp. Coefficient of V_{oc}	%/˚C	-.24						
Temp. Coefficient of I_{sc}	%/˚C	-.02						
Temp. Coefficient of Power	%/˚C	-.26						

System Information

Cell type	Cylindrical CIGS
Maximum System Voltage	Universal design: 1000V (IEC) & 600V (UL) systems
Dimensions	Panel: 1.82 m x 1.08 m x 0.05 m Height: 0.3 m to top of panel on mounts
Mounts	Non-penetrating, powder-coated Aluminum Up to 2.17 mounts per panel
Connectors	4 Tyco Solarlok; 0.20 m cable
Series Fuse Rating	23 Amps
Roof Load	16 kg/m² (3.3 lb/ft²) panel and mounts
Panel Weight	31 kg (68 lb) without mounts
Snow Load Maximum	2800 Pa (58.5 lb/ft²)
Wind Performance	208 km/h (130 mph) maximum Self-ballasting with no attachments
Operating and Storage Temp	-40˚C to +85˚C
Normal Operating Cell Temperature (NOCT)	41.7˚C at 800 W/m², Temp = 20˚C, Wind = 1m/s
Certifications/Listings	UL1703, IEC 61646, CEC listing IEC 61730, IEC 61646, CE Mark Application Class A per IEC 61730-2 Fire Class C
Warranty	25 year limited power warranty 5 year limited product warranty

Solyndra's panels come with all of the mounts, grounding connectors, lateral clips, and fasteners required to build a standard array.

Specifications subject to change without notice.

SOLYNDRA™
The new shape of solar™

Solyndra, Inc. • 47700 Kato Road • Fremont, CA • www.solyndra.com

Revision: 3 / Released: 3/11/09

SolarIntegrated

SI-G1 720

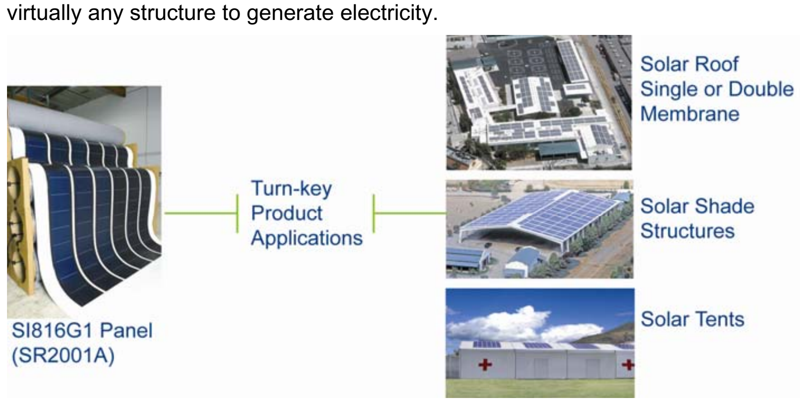
SI-G1 720 Product Information

Solar Panels: Built to Last and Generate Reliable Power

Overview

Ideal for new construction or rooftop replacements, shade structures and solar tents, Solar Integrated's building integrated photovoltaic (BIPV) solar panel is a unique product designed for multiple solar applications. The SI-G1 720, engineered as a weather-tight solar panel, combines low maintenance industrial fabrics with UNI-SOLAR lightweight, amorphous PV cells. The result is a flexible durable solar panel that can be installed on virtually any low slope surface.

Until the introduction of Solar Integrated's BIPV products, the installation of solar panels on industrial rooftops, shade structures or tents was limited due to the heavy weight of rigid crystalline panels. The lightweight Solar Integrated products eliminate this issue and allow virtually any structure to generate electricity.



Key Product Features

- **Lightweight -** The solar panel is the lightest in the industry, weighing only 12 ounces per square foot.
- **Rugged and durable** - Durability to cope with challenging weather conditions and stability to handle changing light and shade conditions are built into our BIPV products. In addition, unlike crystalline panels, our systems incorporate bypass technology enabling power production even when damaged.
- **Powerful** – Amorphous silicon panels enable maximum kilowatt-hour output, producing electricity from a wider spectrum of light than traditional crystalline technology. This feature enables optimum electricity production, even when it is cloudy.
- **Reduced Silicon** – Crystalline solar modules require silicon wafers as a key ingredient. Amorphous silicon technology incorporates a microscopic layer of silicon deposited on a sub-straight. The resulting technology is not affected by silicon shortages.

SI-G1 720 Electrical Specifications

Max Power (Pmax) (Watts)[1]	**720.0**
PTC Power (Pmax PTC) (Watts) [2]	680.89
Max Power Voltage (Vmp) (Volts)	165.0
Max Power Current (Imp) (Amp)	4.37
Open Circuit Voltage (Voc) (Volts)	231.25
Short Circuit Current (Isc) (Amp)	5.3
Temp Coefficient of Isc (%/oC)	+0.10
Temp Coefficient of Voc (%/°C)	-0.38
Temp Coef of Pmax (%/°C)	-0.21
Maximum System Voltage (Volts)	600.0
Series Fuse Rating (Amp)	8.0
Blocking Diode Rating (Amp)	8.0

SI-G1 720 Physical Specifications[3]

Length (ft)	**20.0**
Length (mm)	6096.0
Width (ft)	8.58
Width (mm)	2616.2
Thickness (in)	0.12
Thickness (mm)	3.05
Weight (lb)	123.04
Weight (kg)	55.8

1. Standard Test Conditions (STC): 1000W/M^2 insolation, AM 1.5 spectrum, 25°C cell temperature
2. PV USA Test Conditions (PTC): 800W/M^2 insolation, AM 1.5 spectrum, 1M/S wind speed
3. All Solar roof products are shipped with 2 units per roll. They can be separated in the field to achieve alignment during installation.

Electrical and Safety Certifications and Listings

The Solar Integrated SI-G1 720 solar panel is certified to the following standards:

- Certified to UL 1703 standard for US & Canada
- IECEE CB-FCS
- Class A Fire Rating

Endurance Tested

Solar Integrated's BIPV products have passed UL, IEC and TUV tests for accelerated aging, electrical safety, weather resistance, thermal shock, hail impact and humidity and freeze cycling.

Leveraging More Than 80 Years of Roofing Experience, We've Got You Covered!

Solar Integrated is a leading provider of BIPV products for multiple applications. Contact us for a free layout design of a solar rooftop or shade structure or get a quote for a solar tent. Our team will design a customized system using multiple panels, configured for maximum coverage and electricity output. Go to our website at www.solarintegrated.com and fill in our "Is Solar Right for You?" on-line questionnaire.

SolarIntegrated

Thinking Integrated. Building Integrated.

Solar Integrated
1837 East Martin Luther King Jr. Blvd.
Los Angeles, California, USA 90058

Tel: +1.323.231.0411
Toll Free: +1.888.765.3649
Fax: +1.323.231.0517
Email: sales@solarintegrated.com

www.solarintegrated.com

California Contractors License #820460B;C39;C46

SolarMount®

PV's most versatile mounting system

SolarMount is the most versatile PV mounting rail system on the market today.

We've engineered installer-friendly components for maximum flexibility, allowing you to solve virtually any PV mounting challenge.

The universal SolarMount rail system has three options which can be assembled into a wide variety of PV mounting structures to accommodate any job site.

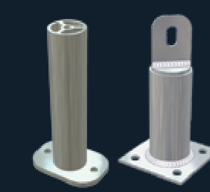
Unirac provides a technical support system complete with installation and code compliance documentation, an on-line estimator and design assistance to help you solve the toughest challenges.

UNIRAC® Bright Thinking in Solar

Visit us online at www.unirac.com

ATTACHMENT OPTIONS

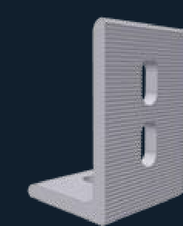
Flexible Components Speed Installation



Standoffs

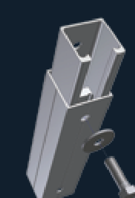
Use standoffs whenever flashed installations are required, on tile roofs, for example. Two-piece aluminum standoff allow precise placement of
a flashing over a secured base prior to the installation of the standoff itself.

All standoff types come in four standard heights: 3, 4, 6, and 7 inches. Appropriate flashings are available.



Serrated L-feet

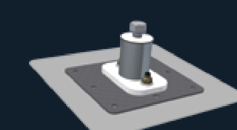
Standard for ground mount installations on residential and commercial rooftops ,use L-feet alone above asphalt composition shingles or in conjunction with flat top standoffs. Mount standard or light rails. Configure to either of two rail heights, one promoting air flow for cooling, the other offering close-to-the-roof aesthetics



Strut-in-Tube Style Legs

Quickly set the precise tilt angle required. Styles are available for high profile (1 or 2 legs per rail) and low profile installations.

Each series offers three leg lengths so that you can adjust to exactly the tilt angle you want—up to a maximum of 60 degrees—without cutting and drilling at the job site.

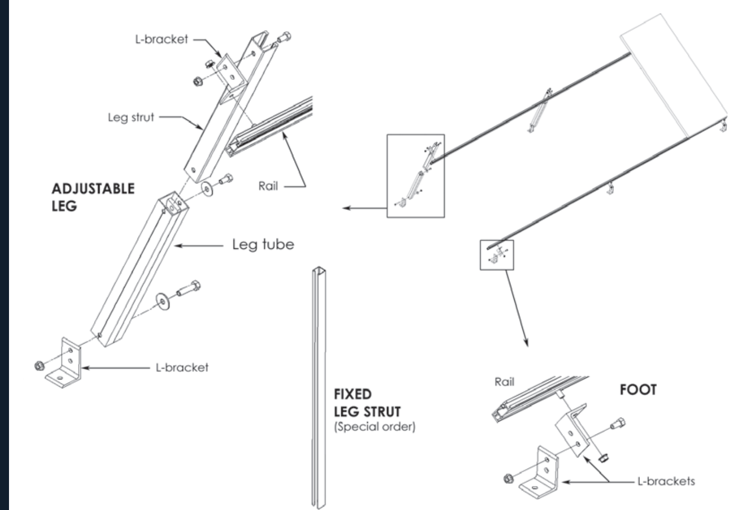


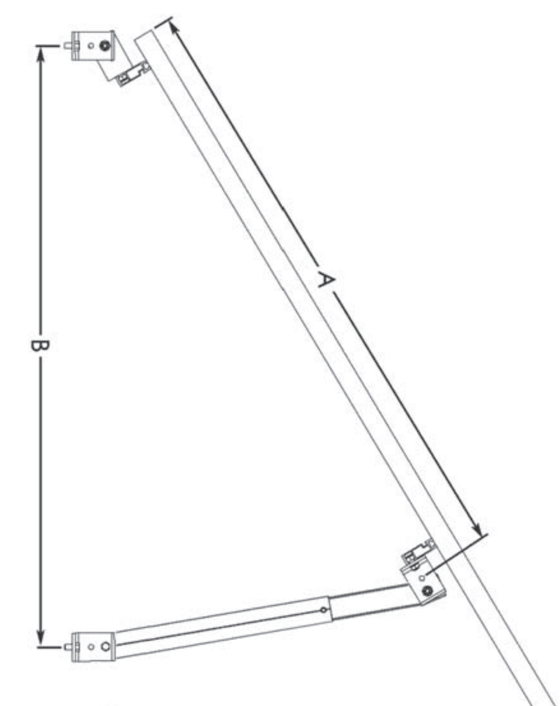
FastFoot™

The FastFoot™ attachment features Eco-Fasten technology by the Alpine Snow Guard Company, allowing attachments to metal, concrete and wood decks without compromising the integrity of the roof.

Tile Hook

Made from cast aluminum, the tile hook attachment provides SolarMount with a cost-effective solution for barrel or Spanish tile roofs. All required lag bolts and hardware are included. Refer to the tile hook engineering data for max load capabilities.





PV/Wind recommended systems

MONITORING ISSUES: Building Dashboard

Ambient Conditions
- o Temperature
- o Relative Humidity
- o Wind Speed
- o Wind direction

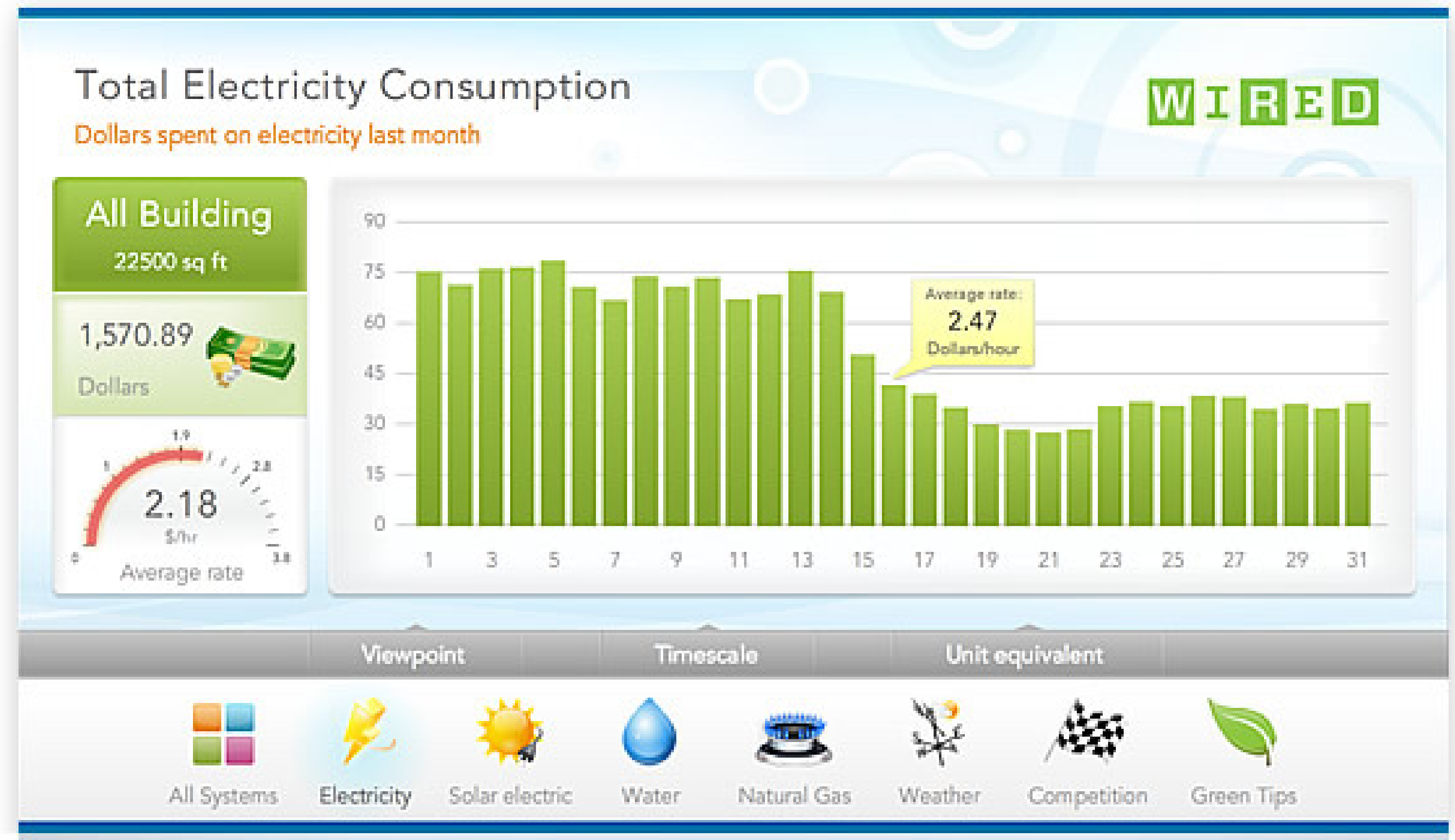
Note: requires data logger and Weather Station (can be quoted by Lucid Design Group)

PV Panel Output
- o Can either be done through separate meters
- o Can be accomplished by interfacing with commercial monitoring systems such as:
- o Fat Spaniel (need separate quote for these)
- o Energy Recommerce (need separate quote for these)

Roof Membrane Temperatures: (these are modules in development by Lucid Design Group, estimate is rough.
- o On existing roof (no PV panel)
- o On existing roof (with lay-on BIPV) – top
- o On existing roof (with lay-on BIPV) – bottom
- o On existing roof (with rack mount system) – in shade

Notes:

1. Will need additional cost for installation, hook up etc. from EDM
2. Additional Estimate by Missouri Solar Living for commercial monitoring System



Lucid Technologies Building Dashboard

RAY Building
PV Awning Impact on Cooling Loads
95% Report
10-7-09

A cooling load analysis was performed for the 5th floor south exterior zone, from column lines A-K. This zone is 185' long x 10' wide, with a floor area of 1850 SF, and is typical for floors 3-10 where the PV panels would be installed over the windows.

The total window area on this exposure is 707.2 SF. The windows are a ½" thick, single pane with a grey tint. These windows were modeled with a Summer U-factor of 0.89, Winter U-factor of 0.98 and a Shading Coefficient of 0.49.

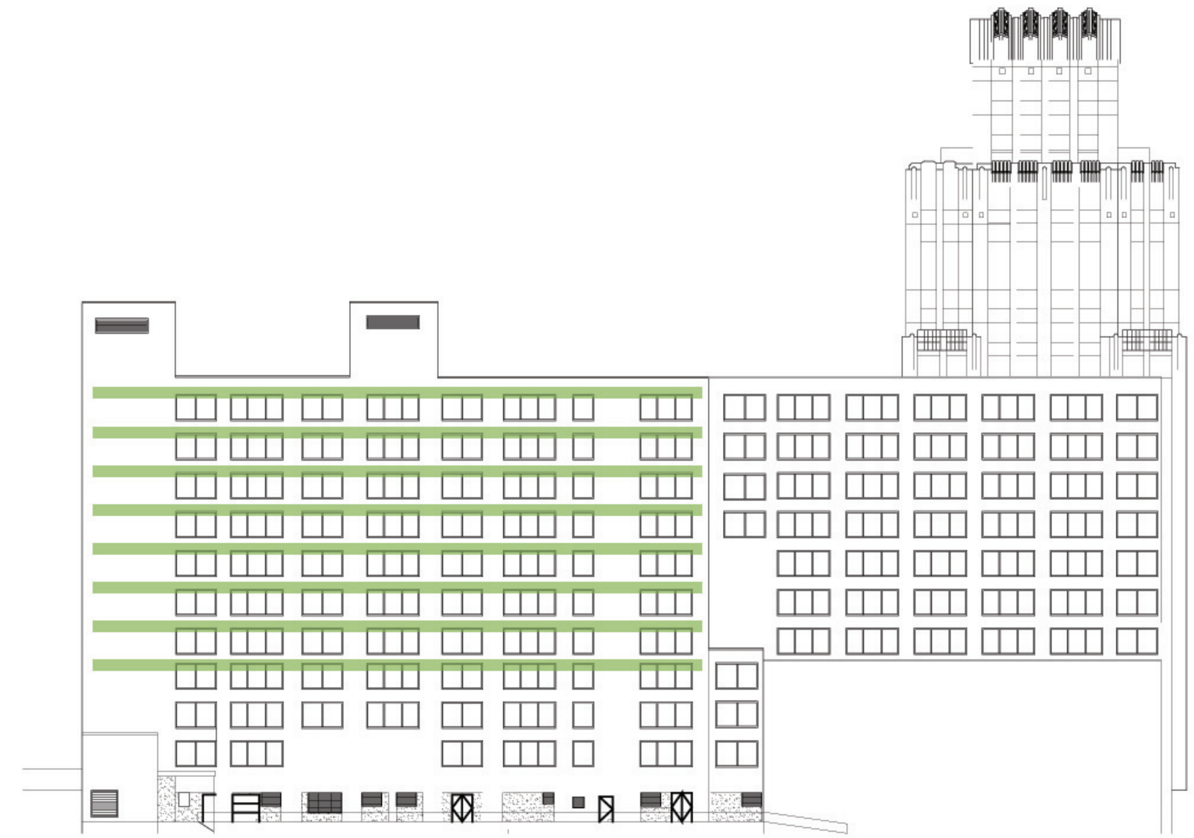
A base load calculation was performed for this zone without the panels installed. The peak load occurs at 2PM in October, with the total cooling load contributed by the glass as 81,639 BTU/Hr, or 6.8 tons. The total cooling load for floors 3-10 contributed by the windows is 54.4 tons.

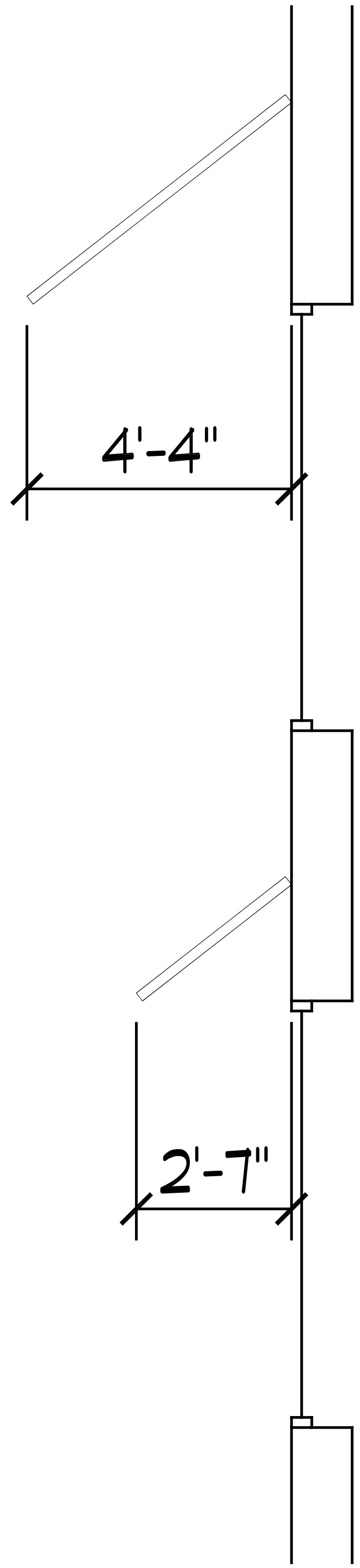
The window shading was modified for the second run to account for a PV awning projecting 37.5" over the windows. The addition of the awning shifted the peak cooling load to 1PM in November. The total cooling load contributed by the glass would be reduced to 61,948 BTU/Hr, or 5.2 tons. The total cooling load for floors 3-10 would be reduced to 41.6 tons, or 24%.

The window shading was modified for the third run to account for a PV awning projecting 65" over the windows. The peak cooling load remained at 1PM in November. The total cooling load contributed by the glass would be reduced to 47,774 BTU/Hr, or 4.0 tons. The total cooling load for floors 3-10 would be reduced to 32.0 tons, or 41%.

This analysis indicates a significant reduction in cooling load with the addition of the awnings. Further study is necessary to determine the actual energy savings potential due to the reduction of the peak cooling load.

Since one of the options which may be recommended in the final Go/No Go report for the ARRA Mechanical project is the replacement of the existing windows, the cooling load reduction due to the awnings with the new, higher performance windows also should be reviewed. The better windows will reduce the base solar load, and also the total load reduction due to the awnings.





PV Awning Section

65" PV Awning Across South Facade

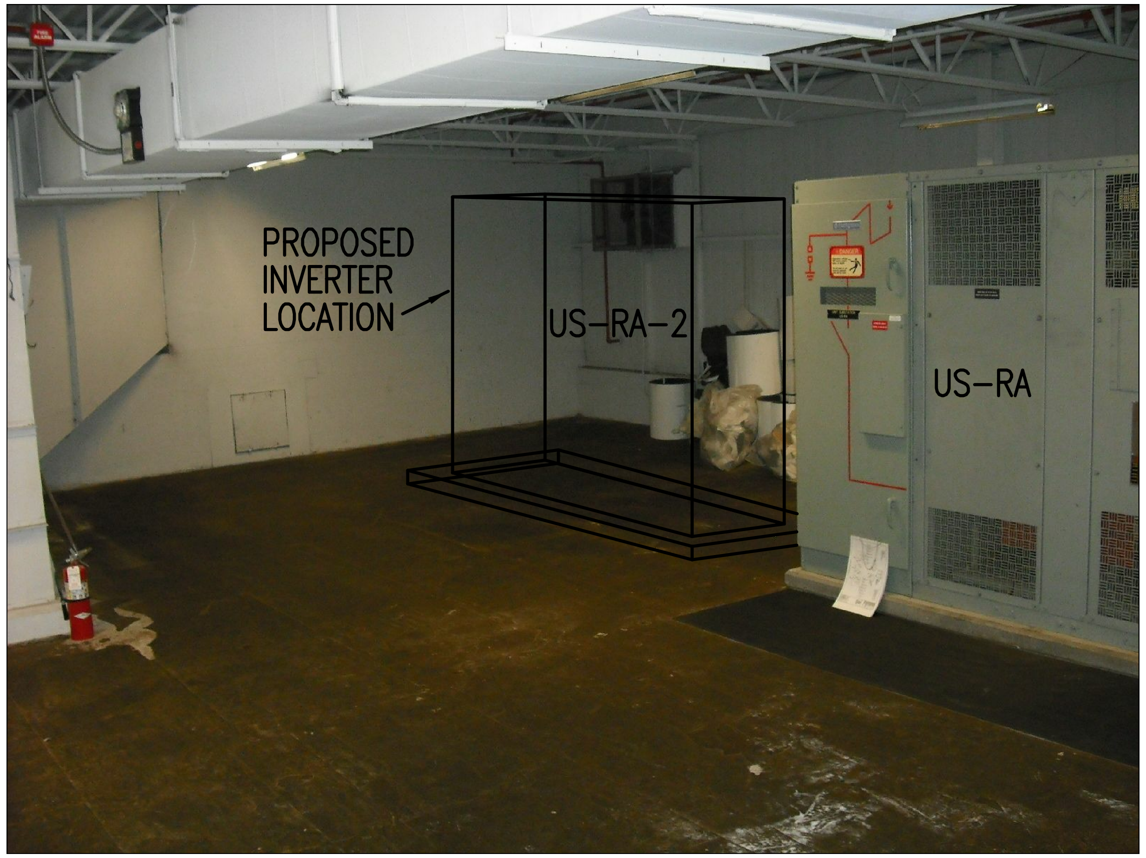
Month	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00
Jan								76.5	63.4	59.9	60.0	62.2	65.9	71.0	77.9	87.3			
Feb							100.0	31.7	35.4	39.5	43.7	48.3	53.5	59.5	66.9	76.4	90.0		
Mar							0.0	0.0	0.0	0.0	14.9	25.6	34.0	41.9	50.2	60.3	74.5	99.1	
Apr						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	19.9	28.8	39.7	68.3	
May					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	69.6	0.0
Jun					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Jul					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.7	0.0
Aug						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	8.3	13.3	53.6	
Sep						0.0	0.0	0.0	0.0	0.0	0.0	13.5	23.9	32.7	41.6	52.1	67.4	98.1	
Oct							0.0	5.0	22.3	31.1	37.8	44.0	50.2	57.3	65.8	77.2	94.2		
Nov							88.9	61.8	55.8	55.2	57.0	60.3	64.9	70.9	78.8	89.7			
Dec								78.7	67.3	63.8	63.8	65.9	69.6	74.9	82.1	92.0			

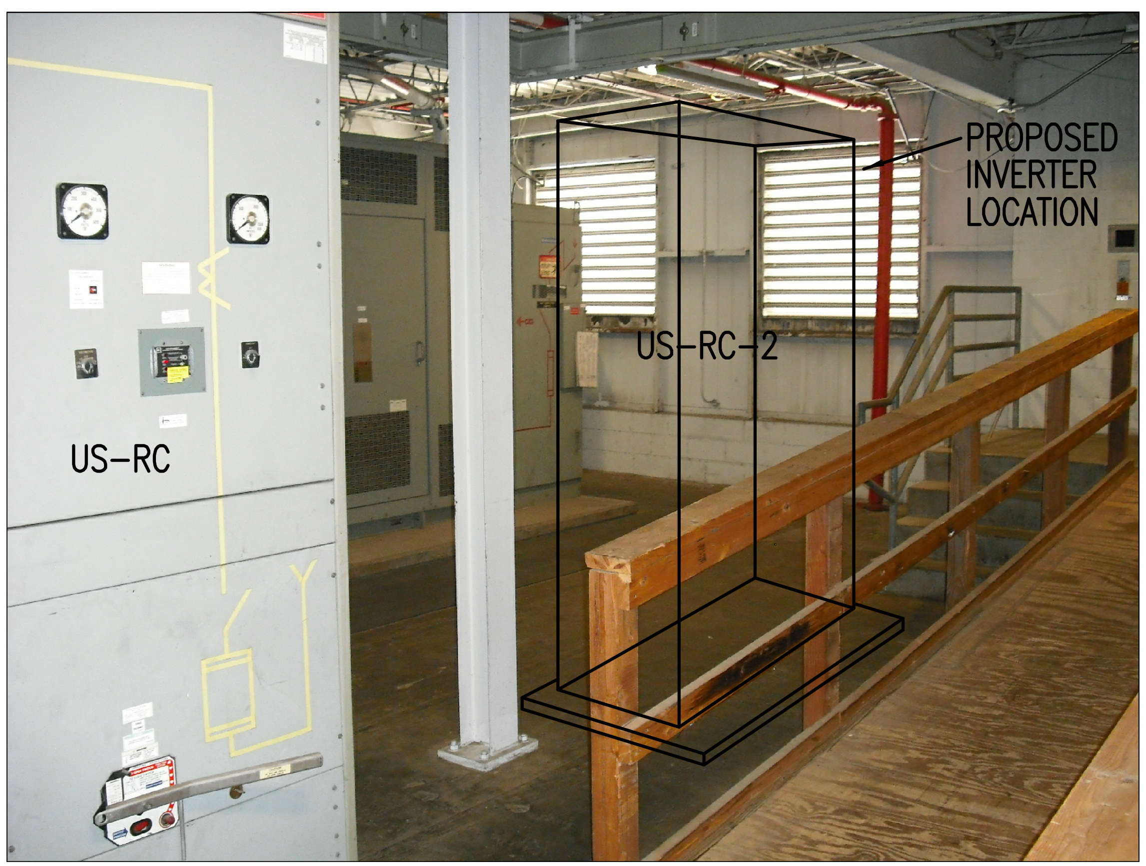
Total average direct sunlight on window surface: 28.70%

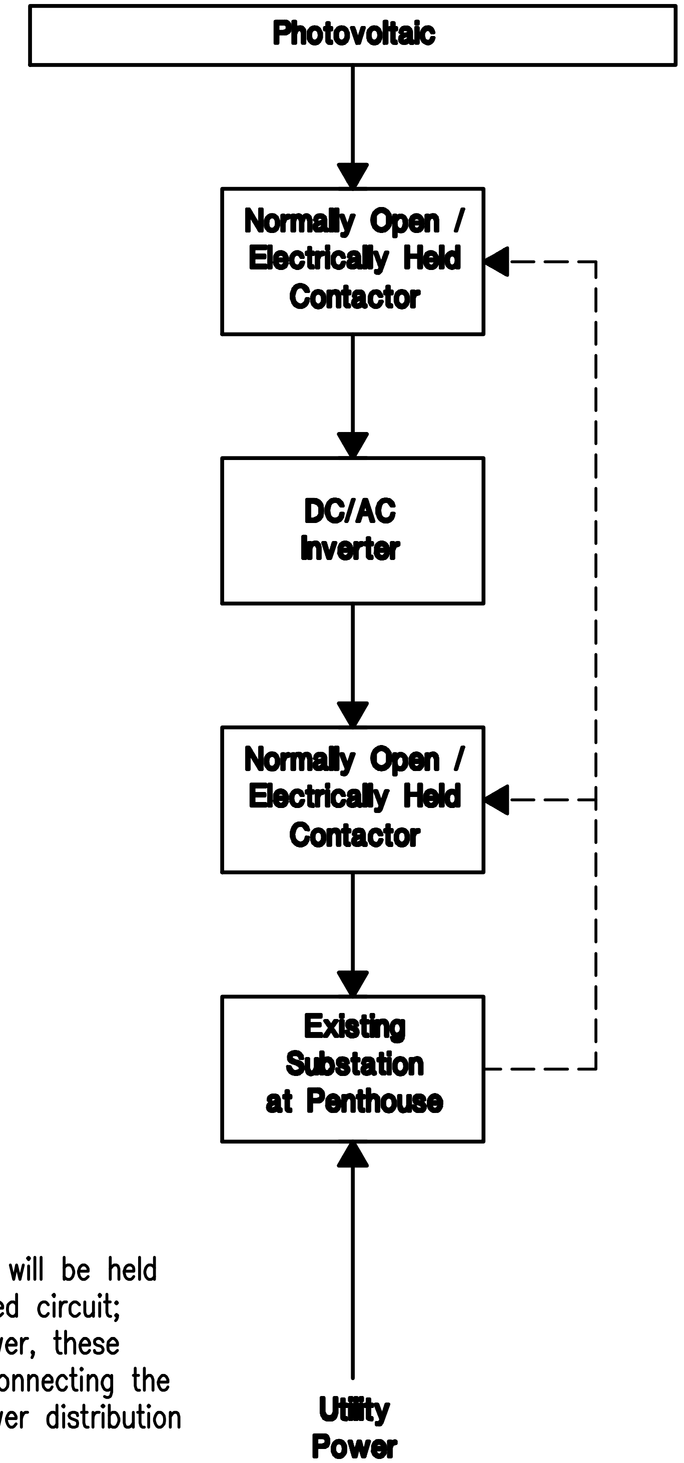
37.5" PV Awning Across South Facade

Month	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00
Jan								86.5	78.9	76.9	77.0	78.2	80.4	83.3	87.3	92.7			
Feb							100.0	60.7	62.9	65.2	67.6	70.3	73.3	76.7	80.9	86.4	94.2		
Mar							0.0	0.0	19.4	41.1	51.0	57.2	62.1	66.6	71.4	77.2	85.3	99.5	
Apr						0.0	0.0	0.0	0.0	0.0	17.0	32.4	41.7	48.4	53.9	59.1	65.3	77.9	
May					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	21.5	26.3	26.6	16.6	50.9	0.0
Jun					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0
Jul					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	12.9	10.7	0.0	33.3	0.0
Aug						0.0	0.0	0.0	0.0	0.0	0.0	16.7	29.3	37.3	42.9	47.1	50.0	52.4	
Sep						0.0	0.0	0.0	0.0	27.5	41.7	50.1	56.2	61.3	66.4	72.5	81.3	98.9	
Oct							0.0	45.2	55.3	60.4	64.3	67.8	71.4	75.4	80.3	86.9	96.7		
Nov							93.6	78.0	74.6	74.3	75.3	77.2	79.8	83.2	87.8	94.0			
Dec								87.7	81.2	79.2	79.2	80.4	82.5	85.5	89.7	95.4			

Total average direct sunlight on window surface: 40.69%



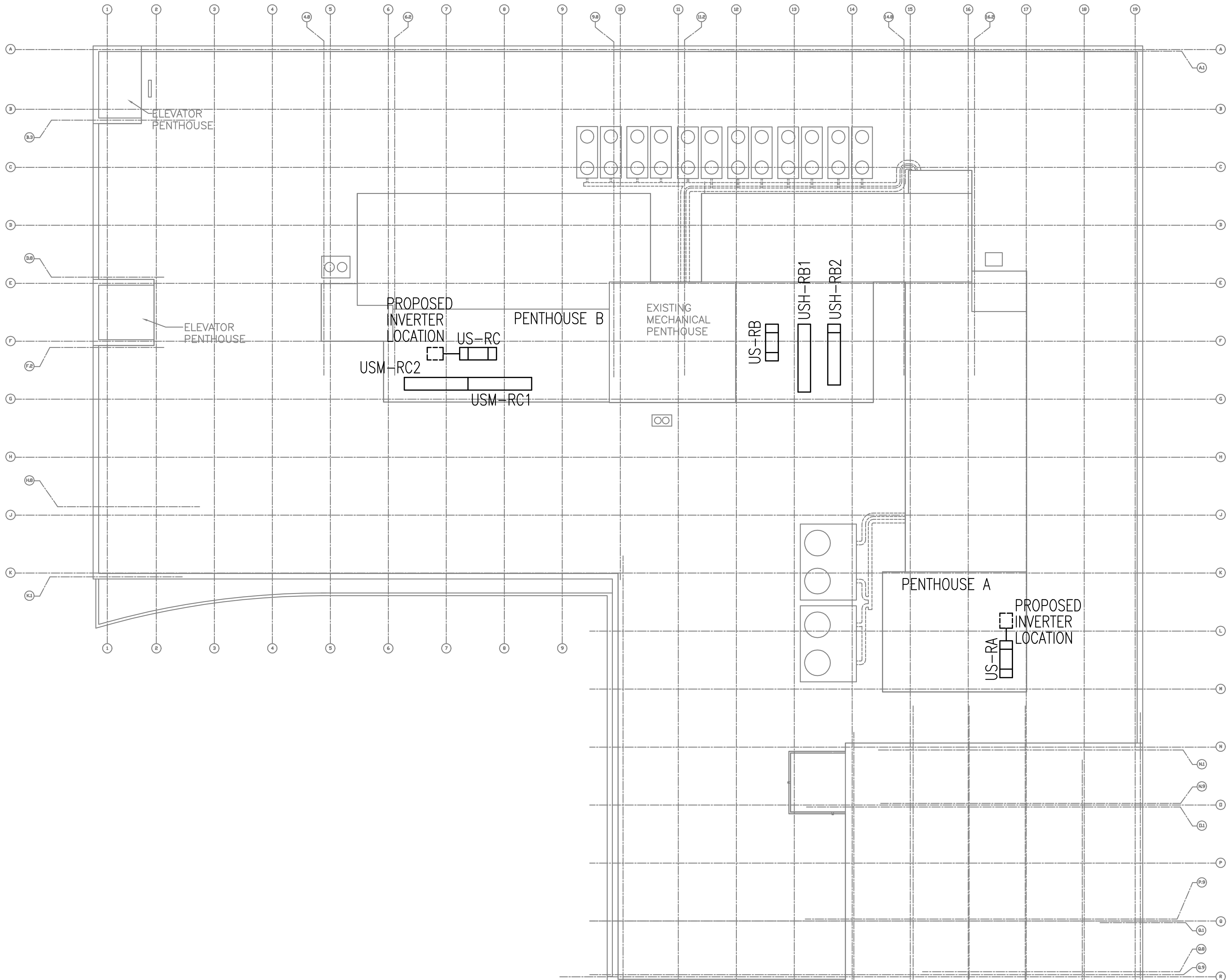




Normally open contactors will be held closed by a utility-powered circuit; Upon failure of utility power, these contactors will open, disconnecting the photovoltaic from the power distribution system.

EDM Incorporated Engineers & Architects 220 Mansion House Center St. Louis, Missouri 63102 (314) 231-5485 Fax: (314) 231-8167 edm@edm-inc.com	Title Electrical Diagram GSA WO-70 RAY Wind Turbine & PV Feasibility	Sheet No. E-1
	EDM Job No. 07828.00 | Date 10/5/09 | By RGH	Reference No.

electrical concept layout



ROOF PLAN – ELECTRICAL

SCALE: 3/64" = 1'-0"

GSA

EDM

hellmuth + bicknese architects

Inverters:

In order to comply with ARRA funding - the inverters will need to meet the "made in America" criteria.

The options are:

- several mid-size inverters such as three or four 30 kW inverters
- microinverters (Enphase) which invert at each panel (an option for typical crystalline modules)
- one larger inverter - for example a single 100kW, 150 kW or 200 kW (the go up to 500kW or a MW)

Two inverter companies that meet criteria for ARRA in the mid to larger size are:

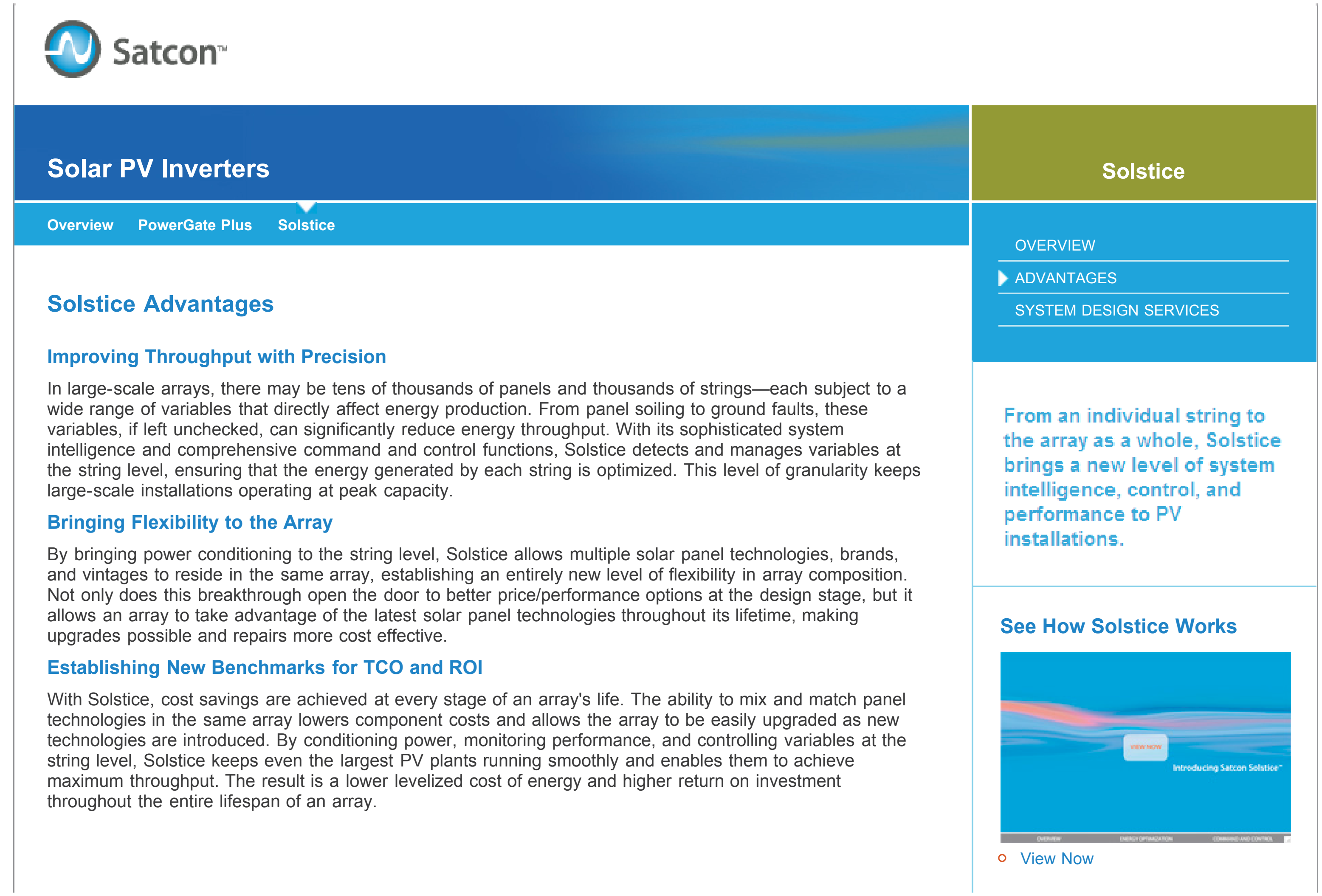
- Satcon
- PV Powered

- (GE may also meet criteria - depending on manufacturing site)

SatCon's Solstice (a newer product) looks especially interesting in that it operates at a string level and, importantly, allows multiple solar panel technologies / brands to be connected to the same inverter

- a possibility for the project. I've attached a screen shot from their website discussing the "solstice advantages". Also attaching a spec sheet on their PowerGate Plus inverter.

Microinverters - small inverters for each module. Enphase is the primary player at this time. These provide the ability to monitor each modules output and limit the affects of shading on some modules without affecting others. Attached is information / spec sheet about Enphase.



Satcon®

PowerGate® Plus 135 kW

PVS-135 (208 V)
PVS-135 (240 V)
PVS-135 (480 V)

Unparalleled Performance

With their advanced system intelligence, next-generation Edge™ MPPT technology, and industrial-grade engineering, PowerGate Plus inverters maximize system uptime and power production, even in cloudy conditions.

Power Efficiency

Power Level	Output Power[1]	Efficiency[2]
10%	13.5 kW	92.9%
20%	27 kW	95.8%
30%	40.5 kW	96.5%
50%	67.5 kW	96.7%
75%	101.25 kW	96.5%
100%	135 kW	96.2%

[1] 310V minimum [2] 480V model

Edge MPPT

Provides rapid and accurate control that boosts PV plant kilowatt yield

Provides a wide range of operation across all photovoltaic cell technologies

Printed Circuit Board Durability

Wide thermal operating range: -40° C (-40° F) to 85° C (185° F)

Conformal coated to withstand extreme humidity and air-pollution levels

Proven Reliability

Rugged and reliable, PowerGate Plus PV inverters are engineered from the ground up to meet the demands of large-scale installations.

Low Maintenance

Modular components make service efficient

Safety

UBC Seismic Zone 4 compliant

Built-in DC and AC disconnect switches

Integrated DC two-pole disconnect switch isolates the inverter (with the exception of the GFDI circuit) from the photovoltaic power system to allow inspection and maintenance

Built-in isolation transformer

Protective covers over exposed power connections

PV Inverters | PowerGate® Plus 135 kW

PowerGate Plus 135 kW Specifications			UL/CSA
Input Parameters			
Maximum Array Input Voltage	600 VDC (UL)		●
Input Voltage Range (MPPT; Full Power)	310–600 VDC	208 VAC	●
	320–600 VDC	240 VAC	●
	310–600 VDC	480 VAC	●
Maximum Input Current	454A DC	208 VAC	●
	440A DC	240 VAC	●
	454A DC	480 VAC	●
Output Parameters			
Output Voltage Range (L-L)	183–229 VAC	208 VAC	●
	211–264 VAC	240 VAC	●
	422–528 VAC	480 VAC	●
Nominal Output Voltage	208 VAC		●
	240 VAC		●
	480 VAC		●
Output Frequency Range	59.3–60.5 Hz		●
AC Voltage Range (Standard)	-12%/+10%		●
Nominal Output Frequency	60 Hz		●
Number of Phases	3		●
Maximum Output Current per Phase	375A	208 VAC	●
	325A	240 VAC	●
	163A	480 VAC	●
CEC-Weighted Efficiency	96%		●
Maximum Continuous Output Power	135 kW (135 kVA)		●
Tare Losses	63.12 W	208 VAC	●
	63.7 W	240 VAC	●
	63.37 W	480 VAC	●
Power Factor at Full Load	>0.99		●
Harmonic Distortion	<3% THD		●

● Standard ○ Optional

Satcon®

PowerGate® Plus 135 kW

Output Options

PowerGate Plus 135 kW

UL/CSA	208 VAC Output
	240 VAC Output
	480 VAC Output

Streamlined Design

With all components encased in a single, space-saving enclosure, PowerGate Plus PV inverters are easy to install, operate, and maintain.

Single Cabinet with Small Footprint

Convenient access to all components

Large in-floor cable glands make access to DC and AC cables easy

Rugged Construction

Engineered for outdoor environments

Output Transformer

Provides galvanic isolation

Matches the output voltage of the PV inverter to the grid

PowerGate Plus 135 kW Specifications		UL/CSA
Temperature		
Operating Ambient Temperature Range (Full Power)	-20° C to +50° C	●
Storage Temperature Range	-30° C to +70° C	●
Cooling	Forced Air	●
Noise		
Noise Level	<65 dB(A)	●
Combiner		
Number of Inputs and Fuse Rating	5 (160A DC)	○
	9 (100A DC)	○
Inverter Cabinet		
Enclosure Rating	NEMA 3R	●
Enclosure Finish (14-Gauge, Powder-Coated G90 Steel)	RAL-7032	●
Cabinet Dimensions (Height x Width x Depth)		80" x 65" x 30.84"
Cabinet Weight		2,684 lbs.
Transformer		
Integrated Internal Transformer		●
Low Tap Voltage[1]	20%	●
Testing and Certification		
UL1741, CSA 107.1-01, IEEE 1547, IEEE C62.41.2, IEEE C62.45, IEEE C37.90.1, IEEE C37.90.2		●
UBC Zone 4 Seismic Rating		●
Warranty		
Five Years		●
Extended Warranty (up to 10, 15, or 20 years)		○
Extended Service Agreement		○
Intelligent Monitoring		
Satcon PV View® Plus		○
Satcon PV Zone		○
Third-Party Compatibility		●

● Standard
○ Optional

[1] The 20% boost tap on the isolation transformer increases the AC voltage output range for applications where the solar array DC operating voltage is at or near the lower end of the DC input range. This boost allows for continued inverter operation at lower DC voltage input levels.

Note: Specifications are subject to change.

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P: 420 255 729 610
F: 420 255 729 611
E sales@satcon.com

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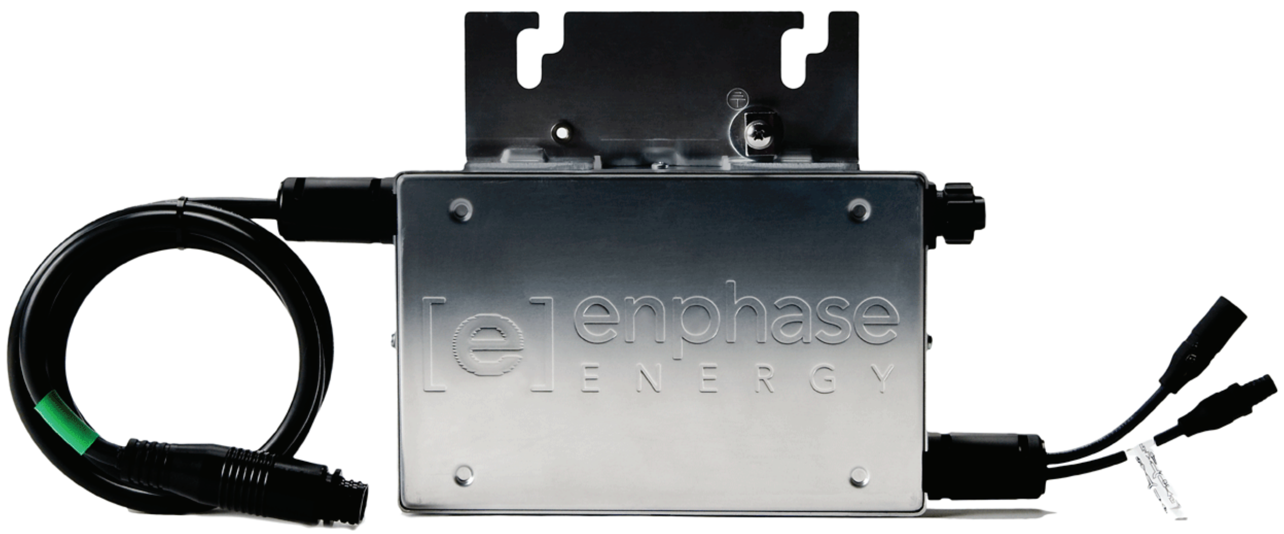
88 FuHua YiLu
Fu Tian District
Shenzhen, China
E sales@satcon.com

[e] ENPHASE MICROINVERTER M190



The Enphase Energy Microinverter System improves energy harvest, increases reliability, and dramatically simplifies design, installation and management of solar power systems. The Enphase System includes the microinverter, the Envoy Communications Gateway, and the web-based Enlighten monitoring and analysis website.

PRODUCTIVE
- Maximum energy production
- Resilient to dust, debris and shading
- Performance monitoring per module

RELIABLE
- MTBF of 331 years
- System availability greater than 99.8%
- No single point of system failure

SMART
- Quick & simple design, installation and management
- 24/7 monitoring and analysis

C US

MICROINVERTER TECHNICAL DATA

60 and 72 Cell Modules

Input Data (DC)	M190-72-208-S11/2/3	M190-72-240-S11/2/3
Recommended input power (STC)	230W	230W
Maximum input DC voltage	54V	54V
Peak power tracking voltage	22V – 40V	22V – 40V
Min./Max. start voltage	28V/54V	28V/54V
Max. DC short circuit current	12A	12A
Max. input current	10A	10A
Output Data (AC)		
Maximum output power	190W	190W
Nominal output current	920mA	800mA
Nominal voltage/range	208V/183V-229V	240V/211V-264V
Extended voltage/range	208V/179V-232V	240V/206V-269V
Nominal frequency/range	60.0/59.3-60.5	60.0/59.3-60.5
Extended frequency/range	60.0/59.2-60.6	60.0/59.2-60.6
Power factor	>0.95	>0.95
Maximum units per branch	21	15
Efficiency		
Peak inverter efficiency	95.5%	95.5%
CEC weighted efficiency	95.0%	95.0%
Nominal MPP tracking	99.6%	99.6%
Mechanical Data		
Operating temperature range	-40°C to +65°C	-40°C to +65°C
Night time power consumption	30mW	30mW
Dimensions (WxHxD)	8″ x 5.25″ x 1.25″	
Weight	4.4 lbs	
Cooling	Natural Convection – No Fans	
Enclosure environmental rating	Outdoor – NEMA 6	
Features		
Communication	Powerline	
Warranty	15 Years	
Compliance	UL1741/IEEE1547 FCC Part 15 Class B	

Inverter Options

Microinverter

The Enphase Microinverter shifts DC to AC conversion from a large, centralized inverter to a compact unit attached directly to each solar module in the power system. Distributing the conversion process to each module makes the entire solar power system more productive, reliable, and smarter than traditional inverter systems.

Download the Microinverter datasheet

Solar Power Challenges

Solar power production is affected by various factors such as module mis-match, obstruction shading, inter-row shading, and obstacles such as dust or debris. In addition, non-uniform changes in temperature, irradiance, and shading create complex current-voltage curves, further affecting energy harvest. This is due to the fact that in traditional systems the performance of the entire system is dictated by the performance of the weakest module.

The Enphase Solution

The Enphase Energy Microinverter System solves solar power challenges by performing Maximum Power Point Tracking (MPPT) at each solar module. MPPT is an algorithm used to calculate and respond to temperature and light changes detected on a solar power system, and to determine how much power to draw from the module. In contrast, centralized inverter's MPPT algorithm sees the entire solar power system as a single module, and responds to the lowest production numbers it detects.

Increased Productivity

The Enphase MPPT algorithm works at each solar module in an installation and achieves greater than 99.6% accuracy which enables it to maximize energy harvest at all times, even during variable light conditions. Tests show systems using Enphase Microinverters increase energy harvest by as much as 25% over systems using traditional inverters.

More Reliable

Traditional centralized inverters implementations create a single point of failure for solar power systems. If the inverter fails, the entire system is disabled. Enphase Microinverters convert power independently at each solar module. If one microinverter fails, the rest continue to operate as usual. Also, if a microinverter is damaged or fails, it can be replaced during routine maintenance or when convenient, further reducing maintenance costs.

Reduced Operational Costs

With the Enphase Microinverter System, installers are no longer limited by string design, marginal designs, co-planarity, and matched modules. The space, heat, and noise associated with a large inverter are eliminated. Enphase Microinverter Systems improve mechanical integration, reduce wiring time, and remove the need for DC switching points.

Flexibility

Another benefit of the distributed microinverter design is the potential for installations to be expanded over time. An initial set of solar modules can be installed and additional modules added as needs and budgets grow without requiring the replacement of a large centralized inverter.

Compliance and Reliability

The Enphase Microinverter is CSA Listed per UL1741 and can withstand surges of up to 6kV. Enphase Microinverter Systems undergo rigorous testing including HALT and HASS, ensuring reliability. Independent testing by Relex – a leading third party reliability expert – has shown an estimated Mean Time Between Failure (MTBF) of 331 years for Enphase Microinverters.

The Enphase Microinverter works in conjunction with the Envoy communications gateway and the Enlighten website.

List and description of analysis

payback analysis - solar

RETScreen Financial Analysis - Power project

Financial parameters

General		
Fuel cost escalation rate	%	5.0%
Inflation rate	%	2.5%
Discount rate	%	6.0%
Project life	yr	40
Finance		
Incentives and grants	$	50,000
Debt ratio	%	
Income tax analysis		

Annual income

Electricity export income		
Electricity exported to grid	MWh	279
Electricity export rate	$/MWh	60.00
Electricity export income	$	16,767
Electricity export escalation rate	%	5.0%
GHG reduction income		
Net GHG reduction	tCO2/yr	263
Net GHG reduction - 40 yrs	tCO2	10,518
Customer premium income (rebate)		
Other income (cost)		
Clean Energy (CE) production income		

Project costs and savings/income summary

Initial costs			
Power system	100.0%	$	1,200,000
Balance of system & misc.	0.0%	$	0
Total initial costs	**100.0%**	**$**	**1,200,000**
Incentives and grants		$	50,000
Annual costs and debt payments			
O&M		$	2,000
Fuel cost - proposed case		$	0
Total annual costs		**$**	**2,000**
Periodic costs (credits)			
User-defined - 10 yrs		$	120,000
Annual savings and income			
Fuel cost - base case		$	0
Electricity export income		$	16,767
Total annual savings and income		**$**	**16,767**

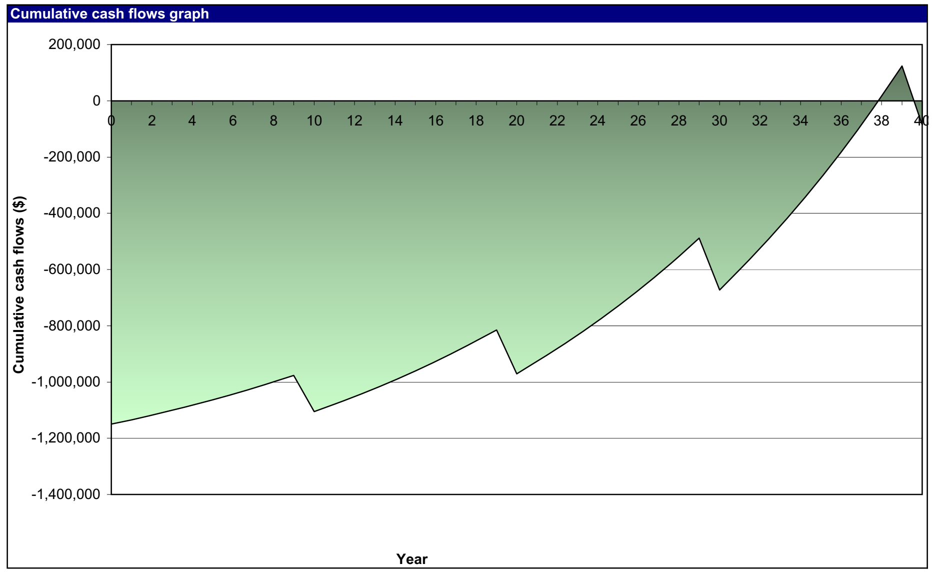
Financial viability

Pre-tax IRR - equity	%	-0.3%
Pre-tax IRR - assets	%	-0.3%
After-tax IRR - equity	%	-0.3%
After-tax IRR - assets	%	-0.3%
Simple payback	yr	77.9
Equity payback	yr	37.8
Net Present Value (NPV)	$	-859,986
Annual life cycle savings	$/yr	-57,156
Benefit-Cost (B-C) ratio		0.28
Energy production cost	$/MWh	152.88
GHG reduction cost	$/tCO2	217

Yearly cash flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	-1,150,000	-1,150,000	-1,150,000
1	15,555	15,555	-1,134,445
2	16,384	16,384	-1,118,061
3	17,256	17,256	-1,100,806
4	18,172	18,172	-1,082,634
5	19,136	19,136	-1,063,498
6	20,149	20,149	-1,043,348
7	21,215	21,215	-1,022,133
8	22,335	22,335	-999,798
9	23,513	23,513	-976,286
10	-128,859	-128,859	-1,105,145
11	26,052	26,052	-1,079,093
12	27,420	27,420	-1,051,673
13	28,859	28,859	-1,022,814
14	30,371	30,371	-992,443
15	31,960	31,960	-960,483
16	33,630	33,630	-926,853
17	35,386	35,386	-891,467
18	37,231	37,231	-854,236
19	39,171	39,171	-815,065
20	-155,425	-155,425	-970,490
21	43,352	43,352	-927,138
22	45,603	45,603	-881,535
23	47,970	47,970	-833,565
24	50,456	50,456	-783,109
25	53,069	53,069	-730,040
26	55,816	55,816	-674,224
27	58,701	58,701	-615,522
28	61,734	61,734	-553,789
29	64,920	64,920	-488,868
30	-183,439	-183,439	-672,307
31	71,787	71,787	-600,520
32	75,484	75,484	-525,036
33	79,368	79,368	-445,668
34	83,450	83,450	-362,218
35	87,738	87,738	-274,480
36	92,244	92,244	-182,237
37	96,977	96,977	-85,260
38	101,951	101,951	16,691
39	107,176	107,176	123,867
40	-209,542	-209,542	-85,674

Cumulative cash flows graph



List and description of analysisList and description of analysis

payback analysis - solar

RETScreen Financial Analysis - Power project

Financial parameters

General		
Fuel cost escalation rate	%	5.0%
Inflation rate	%	2.5%
Discount rate	%	6.0%
Project life	yr	40
Finance		
Incentives and grants	$	50,000
Debt ratio	%	

Income tax analysis

Annual income

Electricity export income		
Electricity exported to grid	MWh	175
Electricity export rate	$/MWh	60.00
Electricity export income	$	10,479
Electricity export escalation rate	%	5.0%
GHG reduction income		
Net GHG reduction	tCO2/yr	164
Net GHG reduction - 40 yrs	tCO2	6,574

Customer premium income (rebate)

Other income (cost)

Clean Energy (CE) production income

Project costs and savings/income summary

Initial costs			
Power system	100.0%	$	843,750
Balance of system & misc.	0.0%	$	0
Total initial costs	**100.0%**	**$**	**843,750**
Incentives and grants		$	50,000
Annual costs and debt payments			
O&M		$	1,250
Fuel cost - proposed case		$	0
Total annual costs		**$**	**1,250**
Periodic costs (credits)			
User-defined - 10 yrs		$	75,000
Annual savings and income			
Fuel cost - base case		$	0
Electricity export income		$	10,479
Total annual savings and income		**$**	**10,479**

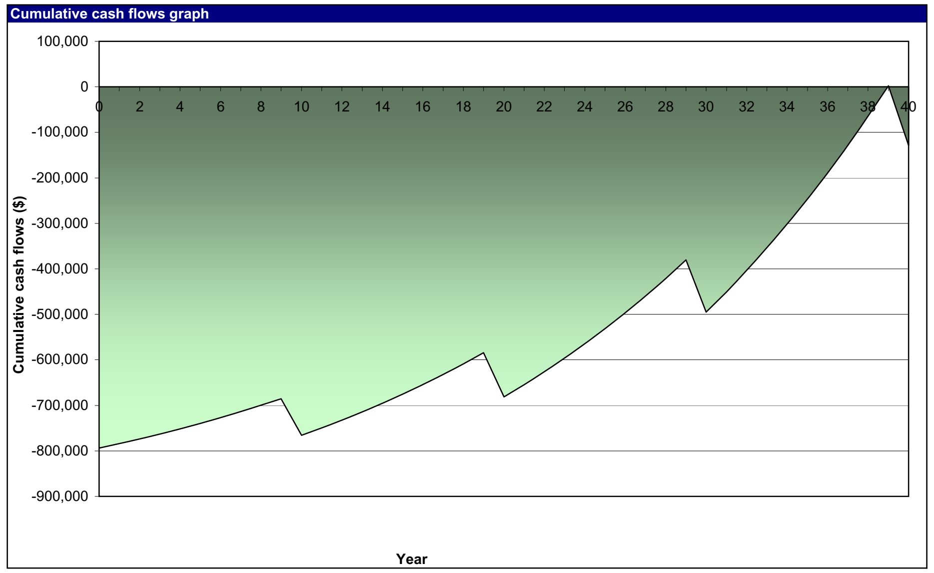
Financial viability

Pre-tax IRR - equity	%	-0.7%
Pre-tax IRR - assets	%	-0.7%
After-tax IRR - equity	%	-0.7%
After-tax IRR - assets	%	-0.7%
Simple payback	yr	86.0
Equity payback	yr	39.0
Net Present Value (NPV)	$	-612,491
Annual life cycle savings	$/yr	-40,707
Benefit-Cost (B-C) ratio		0.27
Energy production cost	$/MWh	165.84
GHG reduction cost	$/tCO2	248

Yearly cash flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	-793,750	-793,750	-793,750
1	9,722	9,722	-784,028
2	10,240	10,240	-773,788
3	10,785	10,785	-763,004
4	11,358	11,358	-751,646
5	11,960	11,960	-739,686
6	12,593	12,593	-727,093
7	13,259	13,259	-713,833
8	13,959	13,959	-699,874
9	14,695	14,695	-685,179
10	-80,537	-80,537	-765,716
11	16,283	16,283	-749,433
12	17,138	17,138	-732,295
13	18,037	18,037	-714,259
14	18,982	18,982	-695,277
15	19,975	19,975	-675,302
16	21,019	21,019	-654,283
17	22,116	22,116	-632,167
18	23,270	23,270	-608,897
19	24,482	24,482	-584,416
20	-97,140	-97,140	-681,556
21	27,095	27,095	-654,461
22	28,502	28,502	-625,959
23	29,981	29,981	-595,978
24	31,535	31,535	-564,443
25	33,168	33,168	-531,275
26	34,885	34,885	-496,390
27	36,688	36,688	-459,702
28	38,584	38,584	-421,118
29	40,575	40,575	-380,543
30	-114,650	-114,650	-495,192
31	44,867	44,867	-450,325
32	47,177	47,177	-403,148
33	49,605	49,605	-353,543
34	52,156	52,156	-301,386
35	54,836	54,836	-246,550
36	57,652	57,652	-188,898
37	60,611	60,611	-128,287
38	63,719	63,719	-64,568
39	66,985	66,985	2,417
40	-130,964	-130,964	-128,546

Cumulative cash flows graph



RETScreen Energy Model - Power project

Show alternative units

Proposed case power system | **Incremental initial costs**

Technology		Wind turbine	
Analysis type		Method 1 / Method 2 / Method 3	
Wind turbine			
Power capacity	kW	2	See product database
Manufacturer		Aeroturbine	
Model		712V	1 unit(s)
Capacity factor	%	15.0%	
Electricity exported to grid	MWh	3	
Electricity export rate	$/MWh	60.00	

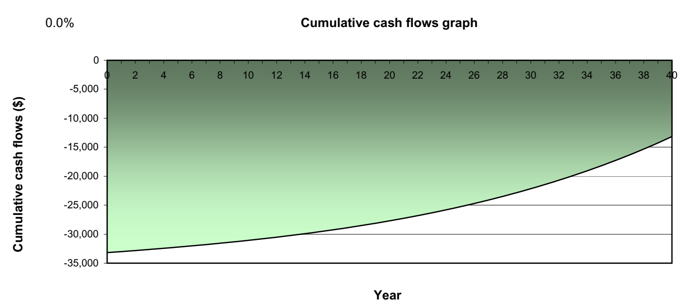
Emission Analysis

Base case electricity system (Baseline) Country - region	Fuel type	GHG emission factor (excl. T&D) tCO2/MWh	T&D losses %	GHG emission factor tCO2/MWh
United States of America	Coal	0.941		0.941

Electricity exported to grid	MWh	3	T&D losses		
GHG emission					
Base case	tCO2	2.5			
Proposed case	tCO2	0.0			
Gross annual GHG emission reductior	tCO2	2.5			
GHG credits transaction fee	%				
Net annual GHG emission reductior	tCO2	2.5	is equivalent to	0.5	Cars & light trucks not used
GHG reduction income					
GHG reduction credit rate	$/tCO2				

Financial Analysis

Financial parameters			
Inflation rate	%	5.0%	
Project life	yr	40	
Debt ratio	%		
Initial costs			
Power system	$	0	0.0%
Other	$	33,162	100.0%
Total initial costs	$	33,162	100.0%
Incentives and grants	$		0.0%
Annual costs and debt payments			
O&M (savings) costs	$		
Fuel cost - proposed case	$	0	
	$		
Total annual costs	$	0	
Annual savings and income			
Fuel cost - base case	$	0	
Electricity export income	$	158	
	$		
Total annual savings and income	$	158	
Financial viability			
Pre-tax IRR - assets	%	-1.8%	
Simple payback	yr	210.3	
Equity payback	yr	> project	



Wind ROI Analysis – Aeroturbine 712 V

Please see RetScreen Analysis (RAY ARRA Wind 712V 12% / 15% documents)

- Assumptions

- Wind speed = 10.3 – 13.2 mph/yr at 150 ft
- Capacity factor run at 12 and 15% (equivalent production from 510V graph extrapolation)
- 510V graph production doubled to estimate 712V production
- 5% electricity rate increase / year
- No incentives applied
- Costs calculated from estimate from Aerotecture (712V Aeroturbine + Solar Estimate)

- Unit cost for wind specific pulled directly from spreadsheet (example: Model 712V = $14,000.
- ½ of the possible combined wind & solar cost assumed for wind (example: inverter unit cost of $3800 / 2 = $1900
- ½ of support services and delivery / installation assumed for wind (example: total cost of design, engineering, administration + total cost design and installation support for 4 combined wind and solar units = $68,100.

  $68,100 / 4 = $17,025 for one combined wind and solar unit

  $17,025 / 2 = $8,512.5 for one wind unit (assumes ½ cost for wind)
- Did not account for monitoring system ($4,000)
- Did not account for shutoffs

Component	Calculations	Cost
Model 712	$14,000 (1)	$14,000
712 Mounting / Support	$5,500 (1)	$5,500
Alternator & Inverter	($4500 + $3,800) / 2	$4,150
Diverter Loads	$700 / 2	$350
Wind Interface Box	$650 (1)	$650
Support Services / Install	$8,512.5 (as above)	$8,512.5
Total		$33,162.50

TOTAL PV - WIND COSTS *10.08.09*

	AMT	UNIT	SUBTOTAL	UNIT	AMT	UNIT	TOTAL	NOTES
PV SYSTEM (combined)	1	LS	$1,200,000				$1,200,000	
	1	LS	$22,000				$22,000	Structural Reinforcement of Rack
								System at Lower Roof
	1	LS	$67,500				$67,500	Structural Reinforcement of Rack
								System at Penthouse Roofs
IF REQUIRED	1	LS	$76,500					Reinforcement for BIPV Membrane
	1	LS	$195,000					Overframing for AHU Penthouse Roofs
	12	EA	$2,500				$30,000	Structural Reinforcement of Rack
								System at Penthouse Roof
	12	EA	$500				$6,000	Roofing Flashing per Garland Spec
VAWT	3	EA	$33,163				$99,488	
	3	EA	$8,000				$24,000	Structural Reinforcement of
								Penthouses
PV AWNINGS								
	8	ROWS	181	FT	1,448	FT		
	1448	LENGTH	5.5	FT	263	FT		
	263	MODULES	205	WATTS	53,971	WATTS		
	$6.50	$/WATT						Base System Cost
	$1.00	$/WATT						Building Height Construction Factor
	$7.50	$/WATT	53,971	WATTS			$404,781.82	
	1	LS	$2,000				$2,000	Electrical Feeder
MONITORING*								
	1	PR	$26,599				$26,599	
	1	LS	$4,000				$4,000	The cost for two (2) 120VAC & two (2)
								Internet Connections
	2	EA	$15,000				$30,000	Fat Spaniel PV/Wind Monitoring
						SUBTOTAL:	**$1,916,368**	
					15%	**CONTINGENCY:**	**$287,455**	
						TOTAL:	**$2,203,824**	

* Based on Lucid Technologies Building Dashboard with 2 kiosks in the lobby of the RAY building (see proposal)

Building Dashboard®

CONFIDENTIAL

Date:	10/5/2009
Client/Project:	GSA - WO #70 RAY ARRA Wind and PV Feasibility Study RAY Federal Building GSA Project #: IMO 00091

Pricing Schedule*

Feature	Quantity	Price EA	Total Price

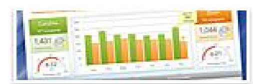
Framework

Building Dashboard® consists of two parts: a standard **Framework** and various add-on **Modules**. The Framework is the data-driven backbone and graphical engine of your display. Among its features are navigation, unique colors and branding, and options for comparing building resource use, showing use over multiple timescales and expressing use in different unit equivalents. The Framework also includes 1 **Introduction** module, 1 **Resource** module and, if you have 3 or more buildings or monitored data points of the same type of resource, 1 **Comparison** module.

Feature	Quantity	Price EA	Total Price
Building Dashboard® Framework	1	*$6,500.00*	$6,500.00
Standard introduction screen **(included)**	1	*$0.00*	$0.00
Advanced introduction screen	0	*$3,450.00*	$0.00
Comparison module **(included with 3+ buildings or data points)**	1	*$0.00*	$0.00

Resource

Resource module



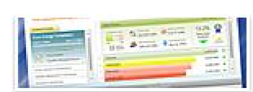
Resource modules are priced according to the number of resources (electricity, water, natural gas, etc.) displayed on a **per building** basis. The first resource in Building 1 is included with the Framework.

Instructions: Mark with a number each resource (electricity, water, natural gas, etc.) that is metered in a building. One Resource module for 1 building is included in the Building Dashboard® Framework. Then, proceed to the following rows and enter the quantity of each resource in each building under the respective heading. For example, if Building 1 includes total electricity use, enter 1 in "Building 1 (included)". If Building 1 includes per floor electricity use across 5 separate floors, enter 1 in "Building 1 (included)", then enter 4 in "Building 1".

	Electricity	Solar electricity	Water	Wind	Rainwater	Natural gas	Steam heat	Chilled water	Solar thermal	Geothermal	*Price of first resource*	*Price of additional resources*		
Building 1		1		1							*$0.00*	*$950.00*	$950.00	
Building 2											*$2,500.00*	*$950.00*	$0.00	
Building 3											*$2,300.00*	*$950.00*	$0.00	
Building 4											*$2,100.00*	*$950.00*	$0.00	
Building 5											*$1,900.00*	*$950.00*	$0.00	
Building 6											*$1,600.00*	*$950.00*	$0.00	
Building 7											*$1,300.00*	*$950.00*	$0.00	
Building 8											*$1,100.00*	*$950.00*	$0.00	
Building 9											*$990.00*	*$950.00*	$0.00	Total
Building 10											*$950.00*	*$950.00*	$0.00	1

Competition

Competition module



1-9 participating buildings or floors	0	*$2,450.00*	$0.00
10+ participating buildings or floors	0	*$3,200.00*	$0.00

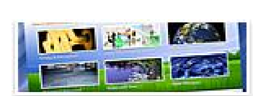
Green Tips

Green Tips module

Standard green tips (50 total screens)	0	*$750.00*	$0.00

Green Features

Green Features module



Custom green features (6 total screens + menu)	0	*$2,450.00*	$0.00
Custom green features (12 total screens + menu)	0	*$2,950.00*	$0.00
Custom green features (18 total screens + menu)	0	*$3,450.00*	$0.00
Custom green features (24 total screens + menu)	0	*$3,950.00*	$0.00

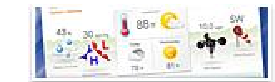
Payback

Payback module for Solar and Thermal Systems

Payback for 1 system	0	*$1,450.00*	$0.00
Payback for 2 systems	0	*$1,950.00*	$0.00
Payback for 3 systems	0	*$2,450.00*	$0.00

Weather

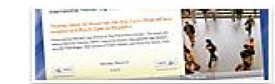
Weather module



Live weather conditions (local temperature, humidity, pressure, wind speed, wind direction + basic forecast)	1	*$750.00*	$750.00

Temperature

Temperature Module



Temperature of various areas of roof - sensors not included	1	*$1,950.00*	$1,950.00

Data Downloader

Data Downloader

Data Downloader web-based application with password protection option and unlimited downloads.	0	*$1,950.00*	$0.00

Hardware

Hardware

Data Acquisition Gateway	1	*$1,849.00*	$1,849.00
Weather Station	1	*$2,950.00*	$2,950.00
Veris or Wattnode Meters	2	*$650.00*	$1,300.00

Touchscreen

Our Touchscreen package includes a 32" ELO LCD touchscreen with a small mini compter. Software: Site kiosk, Site Remote and Team viewr is installed and allows Lucid to continuously monitor uptime, and troubleshoot any issues on the Touchscreen; Computer is custom configured to display Dashboard. Inlcuded in package is a tiltable wall mount that houses the computer and locks it to the screen.

32"-inch ELO LCD Touchscreen Package	1	*$5,950.00*	$5,950.00
42"-inch ELO LCD Touchscreen Package	0	*$8,950.00*	$0.00
Custom Configured Computer only	0	*$1,950.00*	$0.00

Data Integration

Data Integration, configuration and setup
(additional hours billed separately)

Meter Integration	1	*$2,450.00*	$2,450.00
PV ntegration	1	*$950.00*	$950.00

Service

Service

12-month monitoring term of Building Dashboard® Remote Information Service for 1 metered buildings, due on 1st anniversary of activation date. includes software upgrades tech support and hosting of data.	0	*$500.00*	$1,000.00	*$2000 base + $500 each building*

Total

SOFTWARE & SERVICES TOTAL	**$13,550.00**
HARDWARE SUBTOTAL	**$12,049.00**
TOTAL	**$26,599.00**

total cost

GSA

4EDM

hellmuth + bicknese
a r c h i t e c t s

Robert A. Young Federal Building

1222 Spruce Street St. Louis, Missouri

LEED NC Version 3 Project Checklist

Date: 08.28.2009
Project No.: 09008

Certified 40-49 points **Silver** 50-59 points **Gold** 60-79 points **Platinum** 80 points and above **Possible Points 110**

Y	?	N	Sustainable Sites		Possible Points 26
13	5	6			
	?		Prereq 1	**Construction Activity Pollution Prevention**	0
1			Credit 1	**Site Selection**	1
5			Credit 2	**Development Density & Community Connectivity**	5
		1	Credit 3	**Brownfield Redevelopment**	1
4			Credit 4.1	**Alternative Transportation**, Public Transportation Access	6
	1		Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
	3		Credit 4.3	**Alternative Transportation**, Low-Emitting ar	
2			Credit 4.4	**Alternative Transportation**, Parking Capacit	
		1	Credit 5.1	**Site Development**, Protect or Restore Habitat	
		1	Credit 5.2	**Site Development**, Maximize Open Space	
		1	Credit 6.1	**Stormwater Design**, Quantity Control	
		1	Credit 6.2	**Stormwater Design**, Quality Control	
		1	Credit 7.1	**Heat Island Effect**, Non-Roof	
1			Credit 7.2	**Heat Island Effect**, Roof	
	1		Credit 8	**Light Pollution Reduction**	

Y	?	N	Water Efficiency	
0	8	2		
	?		Prereq 1	**Water Use Reduction**
	2		Credit 1.1	**Water Efficient Landscaping**, Reduce by 5(
	2		Credit 1.2	**Water Efficient Landscaping**, No Potable U
		2	Credit 2	**Innovative Wastewater Technologies**
	2		Credit 3.1	**Water Use Reduction**, 30% Reduction
	1		Credit 3.2	**Water Use Reduction**, 35% Reduction
	1		Credit 3.3	**Water Use Reduction**, 40% Reduction

Y	?	N	Energy & Atmosphere		
3	32	0			
	?		Prereq 1	**Fundamental Commissioning of Buildin**	
	?		Prereq 2	**Minimum Energy Performance** (ASHRAE	
	?		Prereq 3	**Fundamental Refrigerant Management**	
	1		Credit 1.1	**Optimize Energy Performance**, 12% New /	
	1		Credit 1.2	**Optimize Energy Performance**, 14% New /	
	1		Credit 1.3	**Optimize Energy Performance**, 16% New /	
	1		Credit 1.4	**Optimize Energy Performance**, 18% New /	
	1		Credit 1.5	**Optimize Energy Performance**, 20% New /	
	1		Credit 1.6	**Optimize Energy Performance**, 22% New /	
	1		Credit 1.7	**Optimize Energy Performance**, 24% New /	
	1		Credit 1.8	**Optimize Energy Performance**, 26% New /	
	1		Credit 1.9	**Optimize Energy Performance**, 28% New /	
	1		Credit 1.10	**Optimize Energy Performance**, 30% New /	
	1		Credit 1.11	**Optimize Energy Performance**, 32% New /	
	1		Credit 1.12	**Optimize Energy Performance**, 34% New /	
	7		Credit 1.13-1.19	**Optimize Energy Performance**, 36-48% Ne	
	1		Credit 2.1	**On-Site Renewable Energy**, 1%	
	1		Credit 2.2	**On-Site Renewable Energy**, 3%	
	1		Credit 2.3	**On-Site Renewable Energy**, 5%	1
	1		Credit 2.4	**On-Site Renewable Energy**, 7%	1
	1		Credit 2.5	**On-Site Renewable Energy**, 9%	1
	1		Credit 2.6	**On-Site Renewable Energy**, 11%	1
	1		Credit 2.7	**On-Site Renewable Energy**, 13%	1
	2		Credit 3	**Enhanced Commissioning**	2
	2		Credit 4	**Enhanced Refrigerant Management**	2
3			Credit 5	**Measurement & Verification**	3
	2		Credit 6	**Green Power**	2
				* in increments of 3.5%	
16	45	8		SUBTOTAL	16

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Energy & Atmosphere

Energy & Atmosphere		Possible Points
Credit 2.1	**On-Site Renewable Energy**, 1%	
Credit 2.2	**On-Site Renewable Energy**, 3%	
Credit 2.3	**On-Site Renewable Energy**, 5%	
Credit 2.4	**On-Site Renewable Energy**, 7%	
Credit 2.5	**On-Site Renewable Energy**, 9%	
Credit 2.6	**On-Site Renewable Energy**, 11%	
Credit 2.7	**On-Site Renewable Energy**, 13%	

*** Up to 8 Potential Points under LEED NCv3**

Robert A. Young Building kWh

KWH Summary 10/5/2009

Meter Number	2007	2008	2009	TOTAL
2838109	8,625,346	8,346,214	7,318,833	24,290,393
2838158	12,149,272	12,609,468	9,553,891	34,312,631
56836763	353	366	302	1,021
TOTAL	20,774,971	20,956,048	16,873,026	58,604,045
kWh produced		200kW 1%		

Robert A. Young Federal Building

1222 Spruce Street St. Louis, Missouri

LEED NC Version 3 Project Checklist

Score 31

Date: 08.28.2009
Project No: 09008

Certified 40-49 points **Silver** 50-59 points **Gold** 60-79 points **Platinum** 60 points and above

Y	?	N	Materials & Resources		Possible Points 14
8	4	2			
Y			Prereq 1	**Storage & Collection of Recyclables**	0
1			Credit 1.1	**Building Reuse**, Maintain 55% of Existing Walls, Floors & Roof	1
1			Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
1			Credit 1.1	**Building Reuse**, Maintain 95% of Existing Walls, Floors & Roof	1
1			Credit 1.2	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
				agement, Divert 50% from Disposal	1
				agement, Divert 75% from Disposal	1
				5%	1
				10%	1
				ost-consumer + ½ pre-consumer)	1
				ost-consumer + ½ pre-consumer)	1
				, 10% Extracted, Processed & Manufactured Regionally	1
				, 20% Extracted, Processed & Manufactured Regionally	1
				rials	1
					1

					Possible Points 15
				ce	0
				Smoke (ETS) **Control**	0
				nitoring (ASHRAE 62.1-2007)	1
					1
				gement Plan, During Construction	1
				gement Plan, Before Occupancy	1
				Adhesives & Sealants	1
				Paints & Coatings	1
				Flooring Systems	1
				Composite Wood & Agrifiber Products	1
				tant Source Control	1
				ns, Lighting	1
				ns, Thermal Comfort	1
					1
				tion	1
				t 75% of Spaces	1
				or 90% of Spaces	1

					Possible Points 6
				een Cleaning	1
				lucation Program	1
					1
					1
					1
1			Credit 2	**LEED™ Accredited Professional**	1

Y	?	N	Regional Priority		Possible Points 4
1	3	0			
1			Credit 1.1	**Regional Priority**	1
	1		Credit 1.2	**Regional Priority**	1
	1		Credit 1.3	**Regional Priority**	1
	1		Credit 1.4	**Regional Priority**	1
15	20	4		SUBTOTAL	31
31 TOTAL POINTS				TOTAL	31

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GSA

hellmuth + bicknese
architects

application in LEED-NC

AUTOMATED PROCEDURES FOR ENGINEERING CONSULTANTS, INC.

Heating/Cooling Load Calculation

HCC-V

Robert A. Young Federal Building
ARRA Wind & PV Study

No PV Panels Installed

Firm: EDM Incorporated
Project Number: 07828
Engineer: GEB
Date: 10/7/9

Weather Station: Missouri
St. Louis AP

Output in I-P units (English)

EXPOSURE DATA

WINDOWS

Id	Dimension Height	Dimension Width	Pct Open	U Values Shade	U Values Sumr	U Values Winter	U Values Frame	Shd Coeff Gls	Shd Coeff Shd	SCR	Description
A	6.8	104.0	95	0.50	0.89	0.98	1.92	0.49	0.49	0	1/2" Monolithic Grey Tint

* - Indicates inside shading is closed.

WINDOWS (Continued)

Id	Overhang Dpth	Overhang Awt	Overhang Bwl	Overhang Bwr	Overhang Vpd	Left Fin Dpth	Left Fin Awt	Left Fin Bwl	Left Fin Bab	Right Fin Dpth	Right Fin Awt	Right Fin Bwr	Right Fin Bab
A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

appendix

EDM Incorporated
RAY Bldg. Wind & PV Study No PV

Project: 07828
APEC HCC-V

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ROOM **501** **South Ext. A-K** SYSTEM **AHU-1** TERMINAL

Room Length	Room Width	Wall Height	Clg Height	Nr. People	Total Watts	Roof ID	Roof Area	Roof RA	Flr ID	Partition ID	Partition Lgth	Hr. Avg	AC/Hr Min.	AC/Hr OSA
185.0	10.0	12.0	9.0	13	2775.							2	0.0	0.0

People Sen.	People Lat.	People Pfl	Lights W/ft²	Lights Pfl	Lights RA	Lights Inc	Equipment Sensible	Equipment Rad.	Equipment Latent	Equipment Pfl	Infil. CFM Summr	Infil. CFM Wintr	H —
250.	200.	A	1.5	A	0		1.5	0	0.	A	0.0	0.0	No

Exposure	Exp Lgth	Wall ID	Wall Area	Wall RA	Window ID	Window Nr.	Window RA	First Shade Azim	First Shade Alt	First Shade Azim	First Shade Alt	Second Shade Azim	Second Shade Alt	Second Shade Azim	Second Shade Alt
S (0) / Vrt (90)	185.0	A	1512.8	0	A	1	0	0	0	0	0	0	0	0	0

PEAK LOAD occurs at 2 PM, October — Heating for 2 DB and -1 WB OSA

	COOLING LOAD Sensible	COOLING LOAD Latent	COOLING LOAD To RA	HEATING LOAD Losses	HEATING LOAD Int. Gain	HEATING LOAD To RA
Window Trans.	7990.		0. **	49388.		
Window Solar	73649.					
Wall Trans.	4466.		0. **	25306.		0.
Wall Solar	4084.					
Roof Trans.	0.		0. **	0.		0.
Roof Solar	0.					
Partition.	0.			0.		
Floor	0.			0.		
Infiltration	0.	0.		0.		
Lights	9463.		0.		9463.	
People	3250.	2600.			3250.	
Equipment	9471.	0.			9471.	
(SF=1.00)						
TOTALS	112372.	2600.	0.	74694.	22184.	0.

TOTAL HEAT 114972. (to room only) — 74694. (to room only)
Sensible heat ratio = 0.98 — 52510. Less Internal Gain

Humidification load due to infiltration: 0.

Air Quantities		Temperatures		Check Figures	
Room Supply	5210.	DTR (Input)	20.0	CFM/ft²	2.8
Room Exhaust	0.	DTR (Actual)	20.0	Cooling, BTUH/ft²	62.1
Room Return	5210.	HTR (Input)	50.0	Cooling, ft²/Ton	193.1
Minimum AC/Hr	0.	HTR (Actual)	0.0	Heating, BTUH/ft²	40.4
Minimum CFM/ft²	0.00	Ret. Air (Peak Hr.)	75.0	AC/Hr.	18.8
Required OA CFM ***	0.0				
Room area =	1850.	Room volume =	16650.	Cooling Design DB	75
				RH%	50
				Heating Design DB	70
				RH%	0

* Indicates inside shading is closed.
** This load to return air includes both transmission and solar.
*** Used to determine OA flow at system level. Actual OA to room depends on room supply air flow and % outside air for the system.

EDM Incorporated
RAY Bldg. Wind & PV Study No PV

Project: 07828
APEC HCC-V

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ROOM **501** **South Ext. A-K** SYSTEM **AHU-1** TERMINAL

Room Name	Peak Mo/Hr	Sens. C. Load	Total C. Load	Sens. Ratio	Room CFM	Heating Load	Room Area	CFM /ft²	Nr. Peop.	DT Htg.
501	10/14	112372.	114972.	0.98	5210.	74694.	1850.	2.82	13	0.0

* Indicates inside shading is closed.

Hour	8	9	10	11	12	13	14
Sensible							
Window Trans.	-3995.	-2663.	-666.	1332.	3995.	5992.	7990.
Window Solar	5579.	23154.	44488.	60402.	70719.	75205.	73649.
Wall Trans.	-2233.	-1489.	-372.	744.	2233.	3349.	4466.
Wall Solar	10949.	10145.	8990.	7865.	6355.	5209.	4084.
Roof Trans.	0.	0.	0.	0.	0.	0.	0.
Roof Solar	0.	0.	0.	0.	0.	0.	0.
Partition.	0.	0.	0.	0.	0.	0.	0.
Floor	0.	0.	0.	0.	0.	0.	0.
Infiltration	0.	0.	0.	0.	0.	0.	0.
Lights to Room	8280.	9463.	9463.	9463.	9463.	9463.	9463.
People	2708.	3250.	3250.	3250.	3250.	3250.	3250.
Equipment	9471.	9471.	9471.	9471.	9471.	9471.	9471.
TOTAL SENSIBLE	30759.	51331.	74624.	92526.	105486.	111939.	112372.
Latent							
Infiltration	0.	0.	0.	0.	0.	0.	0.
People	2600.	2600.	2600.	2600.	2600.	2600.	2600.
Equipment	0.	0.	0.	0.	0.	0.	0.
TOTAL LATENT	2600.	2600.	2600.	2600.	2600.	2600.	2600.
(SF=1.00)							
TOTAL LOAD	33359.	53931.	77224.	95126.	108086.	114539.	114972.

* Indicates inside shading is closed.

Hour	15	16	17	18	19
Sensible					
Window Trans.	9322.	9322.	9322.	7990.	6658.
Window Solar	66132.	52925.	34179.	11830.	118.
Wall Trans.	5210.	5210.	5210.	4466.	3721.
Wall Solar	3339.	3657.	4367.	5807.	7080.
Roof Trans.	0.	0.	0.	0.	0.
Roof Solar	0.	0.	0.	0.	0.
Partition.	0.	0.	0.	0.	0.
Floor	0.	0.	0.	0.	0.
Infiltration	0.	0.	0.	0.	0.
Lights to Room	9463.	9463.	9463.	5914.	2957.
People	3250.	3250.	3250.	2167.	1083.
Equipment	9471.	9471.	9471.	4736.	2368.
TOTAL SENSIBLE	106187.	93297.	75262.	42910.	23985.
Latent					
Infiltration	0.	0.	0.	0.	0.
People	2600.	2600.	2600.	1300.	650.
Equipment	0.	0.	0.	0.	0.
TOTAL LATENT	2600.	2600.	2600.	1300.	650.
(SF=1.00)					
TOTAL LOAD	108787.	95897.	77862.	44210.	24635.

HEATING LOAD for 2°F OSA

Window	49388.
Wall	25306.
Roof	0.
Partition	0.
Floor	0.
Infiltration	0.
Total	74694.

Summaries

Area	1850.	ft²
Volume	16650.	ft³
People	13	
Infiltration		CFM
BTUH/ft² Clg.	62.1	
BTUH/ft² Htg.	40.4	
	5210.	CFM
AC/Hour	18.8	
Htg. DT =	0.0	

EDM Incorporated | Project: 07828 | 10/07/09
RAY Bldg. Wind & PV Study No PV | APEC HCC-V | Page 13

SYSTEM **AHU-1** Variable Volume PEAK LOAD occurs at 2 PM, October

	COOLING LOAD			HEATING LOAD		
	Sensible	Latent	To RA	Losses	Int. Gain	To RA
Window Trans.	7990.		0.**	49388.		
Window Solar	73649.					
Wall Trans.	4466.		0.**	25306.		0.
Wall Solar	4084.					
Roof/Ceiling	0.		0.**	0.		0.
Roof Solar	0.					
Partition.	0.			0.		
Floor	0.			0.		
Infiltration	0.	0.		0.		
Lights*	9463.		0.		9463.	
People*	3250.	2600.			3250.	
Equipment* (SF=1.00)	9471.	0.			9471.	
TOTALS	112372.	2600.	0. ***	74694.	22184.	0.

TOTAL HEAT 114972. (to room only) | 74694. (to room only)
+ 0. Plenum or RA heat
Sensible heat ratio = 0.98 | + 0. Ventilation
Humidification load due to infiltration: 0.
Humidification load due to ventilation: 0. | 74694. Total + 0. Humidification
There are 0 additional duplicates of this system.
74694. Total

Ventilation Air (Air quantity used for ventilation load marked *)

Fixed CFM Input At						0.	
0.00	Pct. Supply Air	x	5210.	CFM	=	0.	CFM
0.00	CFM/Person	x	13.	People	=	0.	CFM
0.00	Air Changes/Hr.	x	16650.	ft³/60.	=	0.	CFM
0.00	CFM/ft²	x	1850.	ft²	=	0.	CFM
Sum of OSA required for all rooms in this system					=	0.	CFM

COOLING LOADS (SF=1.00)

	To Rooms		RA Plen		Dir To RA		Ventilation		Motor		Sys Anal Adj		Total
Sensible	112372.	+	0.	+	0.	+	0.	+	14898.	+	5.	=	127275.
Latent	2600.	+					0.			+	-463.	=	2137.

TOTAL COOLING LOAD 129412. BTUH 10.78 TONS
System cooling load calculated with contribution of systems analysis.

AIR QUANTITIES			CHECK FIGURES			
Supply air sum of room peaks	5210.	CFM	CFM/ft²	2.82	AC/Hr	18.8
Supply air at system peak	5210.	CFM	CFM/ft²	2.82	AC/Hr	18.8
Exhaust air	0.	CFM	Cooling	70.	BTUH/ft²	
			Cooling	172.	ft²/TON	
Infiltration (summer)	0.	CFM	Heating	40.	BTUH/ft²	
Infiltration (winter)	0.	CFM	Humidification	0.	BTUH/ft²	

Lights installed in rooms of system = 2775. Watts After diversity = 2775. Watts
Number of people in rooms of system = 13. After diversity = 13.

* Diversity factors, and/or occupant limit, if input, applied to these loads.
** This load to return air includes both transmission and solar.
*** Total Heat to RA and/or RA Plen reflects potential offset by Vent. CFM.

AUTOMATED PROCEDURES FOR ENGINEERING CONSULTANTS, INC.

Heating/Cooling Load Calculation

HCC-V

Robert A. Young Federal Building
ARRA Wind & PV Study

PV Panels Installed
37.5" Projection

Firm: EDM Incorporated
Project Number: 07828
Engineer: GEB
Date: 10/7/9

Weather Station: Missouri
St. Louis AP

Output in I-P units (English)

EXPOSURE DATA

WINDOWS

Id	Dimension		Pct	U Values				Shd Coeff			Description
	Height	Width	Open	Shade	Sumr	Winter	Frame	Gls	Shd	SCR	
A	6.8	104.0	95	0.50	0.89	0.98	1.92	0.49	0.49	0	1/2" Monolithic Grey Tint

* - Indicates inside shading is closed.

WINDOWS (Continued)

Id	Overhang					Left Fin				Right Fin			
	Dpth	Awt	Bwl	Bwr	Vpd	Dpth	Awt	Bwl	Bab	Dpth	Awt	Bwr	Bab
A	3.1	0.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ROOM **501** **South Ext. A-K** SYSTEM **AHU-1** TERMINAL

Room Length	Room Width	Wall Height	Clg Height	Nr. People	Total Watts	Roof ID	Roof Area	Roof RA	Flr ID	Partition ID	Partition Lgth	Hr. Avg	AC/Hr Min.	AC/Hr OSA
185.0	10.0	12.0	9.0	13	2775.							2	0.0	0.0

People Sen.	People Lat.	People Pfl	Lights W/ft²	Lights Pfl	Lights RA	Lights Inc	Equipment Sensible	Equipment Rad.	Equipment Latent	Equipment Pfl	Infil. CFM Summr	Infil. CFM Wintr	H —
250.	200.	A	1.5	A	0		1.5	0	0.	A	0.0	0.0	No

Exposure	Exp Lgth	Wall ID	Wall Area	Wall RA	Window ID	Window Nr.	Window RA	First Shade Azim	First Shade Alt	First Shade Azim	First Shade Alt	Second Shade Azim	Second Shade Alt	Second Shade Azim	Second Shade Alt
S (0) / Vrt (90)	185.0	A	1512.8	0	A	1	0	0	0	0	0	0	0	0	0

PEAK LOAD occurs at 1 PM, November   Heating for 2 DB and -1 WB OSA

	COOLING LOAD Sensible	Latent	To RA	HEATING LOAD Losses	Int. Gain	To RA
Window Trans.	1332.		0. **	49388.		
Window Solar	60616.					
Wall Trans.	744.		0. **	25306.		0.
Wall Solar	4149.					
Roof Trans.	0.		0. **	0.		0.
Roof Solar	0.					
Partition.	0.			0.		
Floor	0.			0.		
Infiltration	0.	0.		0.		
Lights	9463.		0.		9463.	
People	3250.	2600.			3250.	
Equipment	9471.	0.			9471.	
(SF=1.00)						
TOTALS	89024.	2600.	0.	74694.	22184.	0.

TOTAL HEAT 91624. (to room only)   74694. (to room only)
Sensible heat ratio = 0.97   52510. Less Internal Gain

Humidification load due to infiltration: 0.

Air Quantities		Temperatures		Check Figures	
Room Supply	4130.	DTR (Input)	20.0	CFM/ft²	2.2
Room Exhaust	0.	DTR (Actual)	20.0	Cooling, BTUH/ft²	49.5
Room Return	4130.	HTR (Input)	50.0	Cooling, ft²/Ton	242.3
Minimum AC/Hr	0.	HTR (Actual)	0.0	Heating, BTUH/ft²	40.4
Minimum CFM/ft²	0.00	Ret. Air (Peak Hr.)	75.0	AC/Hr.	14.9
Required OA CFM ***	0.0				
Room area =	1850.	Room volume =	16650.	Cooling Design DB	75
				RH%	50
				Heating Design DB	70
				RH%	0

* Indicates inside shading is closed.
** This load to return air includes both transmission and solar.
*** Used to determine OA flow at system level. Actual OA to room depends on room supply air flow and % outside air for the system.

ROOM **501** **South Ext. A-K** SYSTEM **AHU-1** TERMINAL

Room Name	Peak Mo/Hr	Sens. C. Load	Total C. Load	Sens. Ratio	Room CFM	Heating Load	Room Area	CFM /ft²	Nr. Peop.	DT Htg.
501	11/13	89024.	91624.	0.97	4130.	74694.	1850.	2.23	13	0.0

* Indicates inside shading is closed.

Hour	8	9	10	11	12	13	14
Sensible							
Window Trans.	-8656.	-7324.	-4661.	-2663.	-666.	1332.	2663.
Window Solar	14390.	37328.	50847.	58397.	61552.	60616.	55512.
Wall Trans.	-4838.	-4094.	-2605.	-1489.	-372.	744.	1489.
Wall Solar	9838.	9046.	7549.	6412.	5286.	4149.	3396.
Roof Trans.	0.	0.	0.	0.	0.	0.	0.
Roof Solar	0.	0.	0.	0.	0.	0.	0.
Partition.	0.	0.	0.	0.	0.	0.	0.
Floor	0.	0.	0.	0.	0.	0.	0.
Infiltration	0.	0.	0.	0.	0.	0.	0.
Lights to Room	8280.	9463.	9463.	9463.	9463.	9463.	9463.
People	2708.	3250.	3250.	3250.	3250.	3250.	3250.
Equipment	9471.	9471.	9471.	9471.	9471.	9471.	9471.
TOTAL SENSIBLE	31194.	57141.	73314.	82840.	87984.	89024.	85244.
Latent							
Infiltration	0.	0.	0.	0.	0.	0.	0.
People	2600.	2600.	2600.	2600.	2600.	2600.	2600.
Equipment	0.	0.	0.	0.	0.	0.	0.
TOTAL LATENT	2600.	2600.	2600.	2600.	2600.	2600.	2600.
(SF=1.00)							
TOTAL LOAD	33794.	59741.	75914.	85440.	90584.	91624.	87844.

* Indicates inside shading is closed.

Hour	15	16	17	18	19
Sensible					
Window Trans.	2663.	2663.	1332.	0.	-1997.
Window Solar	45584.	27557.	7919.	0.	0.
Wall Trans.	1489.	1489.	744.	0.	-1116.
Wall Solar	3417.	4238.	5880.	7261.	8785.
Roof Trans.	0.	0.	0.	0.	0.
Roof Solar	0.	0.	0.	0.	0.
Partition.	0.	0.	0.	0.	0.
Floor	0.	0.	0.	0.	0.
Infiltration	0.	0.	0.	0.	0.
Lights to Room	9463.	9463.	9463.	5914.	2957.
People	3250.	3250.	3250.	2167.	1083.
Equipment	9471.	9471.	9471.	4736.	2368.
TOTAL SENSIBLE	75337.	58131.	38058.	20077.	12080.
Latent					
Infiltration	0.	0.	0.	0.	0.
People	2600.	2600.	2600.	1300.	650.
Equipment	0.	0.	0.	0.	0.
TOTAL LATENT	2600.	2600.	2600.	1300.	650.
(SF=1.00)					
TOTAL LOAD	77937.	60731.	40658.	21377.	12730.

HEATING LOAD for 2°F OSA

Window	49388.
Wall	25306.
Roof	0.
Partition	0.
Floor	0.
Infiltration	0.
Total	74694.

Summaries

Area	1850.	ft²
Volume	16650.	ft³
People	13	
Infiltration		CFM
BTUH/ft² Clg.	49.5	
BTUH/ft² Htg.	40.4	
	4130.	CFM
AC/Hour	14.9	
Htg. DT =	0.0	

appendix

SYSTEM **AHU-1** Variable Volume PEAK LOAD occurs at 1 PM, November

	COOLING LOAD			HEATING LOAD		
	Sensible	Latent	To RA	Losses	Int. Gain	To RA
Window Trans.	1332.		0.**	49388.		
Window Solar	60616.					
Wall Trans.	744.		0.**	25306.		0.
Wall Solar	4149.					
Roof/Ceiling	0.		0.**	0.		0.
Roof Solar	0.					
Partition.	0.			0.		
Floor	0.			0.		
Infiltration	0.	0.		0.		
Lights*	9463.		0.		9463.	
People*	3250.	2600.			3250.	
Equipment*	9471.	0.			9471.	
(SF=1.00)						
TOTALS	89024.	2600.	0. ***	74694.	22184.	0.

TOTAL HEAT 91624. (to room only)

Sensible heat ratio = 0.97
Humidification load due to infiltration: 0.
Humidification load due to ventilation: 0.
There are 0 additional duplicates of this system.

74694. (to room only)
\+ 0. Plenum or RA heat
\+ 0. Ventilation
74694. Total + 0. Humidification
74694. Total

Ventilation Air (Air quantity used for ventilation load marked *)

Fixed CFM Input At						0.	
0.00	Pct. Supply Air	x	4130.	CFM	=	0.	CFM
0.00	CFM/Person	x	13.	People	=	0.	CFM
0.00	Air Changes/Hr.	x	16650.	ft³/60.	=	0.	CFM
0.00	CFM/ft²	x	1850.	ft²	=	0.	CFM
Sum of OSA required for all rooms in this system					=	0.	CFM

COOLING LOADS (SF=1.00)

	To Rooms		RA Plen		Dir To RA		Ventilation		Motor		Sys Anal Adj		Total
Sensible	89024.	+	0.	+	0.	+	0.	+	11810.	+	57.	=	100892.
Latent	2600.	+					-0.			+	-357.	=	2243.

TOTAL COOLING LOAD 103135. BTUH 8.59 TONS
System cooling load calculated with contribution of systems analysis.

AIR QUANTITIES			CHECK FIGURES		
Supply air sum of room peaks	4130.	CFM	CFM/ft²	2.23	AC/Hr 14.9
Supply air at system peak	4130.	CFM	CFM/ft²	2.23	AC/Hr 14.9
Exhaust air	0.	CFM	Cooling	56.	BTUH/ft²
			Cooling	215.	ft²/TON
Infiltration (summer)	0.	CFM	Heating	40.	BTUH/ft²
Infiltration (winter)	0.	CFM	Humidification	0.	BTUH/ft²

Lights installed in rooms of system = 2775. Watts After diversity = 2775. Watts
Number of people in rooms of system = 13. After diversity = 13.

* Diversity factors, and/or occupant limit, if input, applied to these loads.
** This load to return air includes both transmission and solar.
*** Total Heat to RA and/or RA Plen reflects potential offset by Vent. CFM.

appendix

AUTOMATED PROCEDURES FOR ENGINEERING CONSULTANTS, INC.

Heating/Cooling Load Calculation

HCC-V

Robert A. Young Federal Building
ARRA Wind & PV Study

PV Panels Installed
65" Projection

Firm: EDM Incorporated
Project Number: 07828
Engineer: GEB
Date: 10/7/9

Weather Station: Missouri
St. Louis AP

Output in I-P units (English)

EXPOSURE DATA

WINDOWS

Id	Dimension Height	Dimension Width	Pct Open	U Values Shade	U Values Sumr	U Values Winter	U Values Frame	Shd Coeff Gls	Shd Coeff Shd	SCR	Description
A	6.8	104.0	95	0.50	0.89	0.98	1.92	0.49	0.49	0	1/2" Monolithic Grey Tint

* - Indicates inside shading is closed.

WINDOWS (Continued)

Id	Overhang Dpth	Overhang Awt	Overhang Bwl	Overhang Bwr	Overhang Vpd	Left Fin Dpth	Left Fin Awt	Left Fin Bwl	Left Fin Bab	Right Fin Dpth	Right Fin Awt	Right Fin Bwr	Right Fin Bab
A	5.4	0.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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RAY Bldg. Wind & PV Study PV65
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10/07/09
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ROOM **501** **South Ext. A-K** SYSTEM **AHU-1** TERMINAL

Room Length	Room Width	Wall Height	Clg Height	Nr. People	Total Watts	Roof ID	Roof Area	Roof RA	Flr ID	Partition ID	Partition Lgth	Hr. Avg	AC/Hr Min.	AC/Hr OSA
185.0	10.0	12.0	9.0	13	2775.							2	0.0	0.0

People Sen.	People Lat.	People Pfl	Lights W/ft²	Lights Pfl	Lights RA	Lights Inc	Equipment Sensible	Equipment Rad.	Equipment Latent	Equipment Pfl	Infil. CFM Summr	Infil. CFM Wintr	H —
250.	200.	A	1.5	A	0		1.5	0	0.	A	0.0	0.0	No

Exposure	Exp Lgth	Wall ID	Wall Area	Wall RA	Window ID	Window Nr.	Window RA	First Shade Azim	First Shade Alt	First Shade Azim	First Shade Alt	Second Shade Azim	Second Shade Alt	Second Shade Azim	Second Shade Alt
S (0) / Vrt (90)	185.0	A	1512.8	0	A	1	0	0	0	0	0	0	0	0	0

PEAK LOAD occurs at 1 PM, November — Heating for 2 DB and -1 WB OSA

	COOLING LOAD Sensible	COOLING LOAD Latent	COOLING LOAD To RA	HEATING LOAD Losses	HEATING LOAD Int. Gain	HEATING LOAD To RA
Window Trans.	1332.		0. **	49388.		
Window Solar	46442.					
Wall Trans.	744.		0. **	25306.		0.
Wall Solar	4149.					
Roof Trans.	0.		0. **	0.		0.
Roof Solar	0.					
Partition.	0.			0.		
Floor	0.			0.		
Infiltration	0.	0.		0.		
Lights	9463.		0.		9463.	
People	3250.	2600.			3250.	
Equipment	9471.	0.			9471.	
(SF=1.00)						
TOTALS	74851.	2600.	0.	74694.	22184.	0.

TOTAL HEAT 77451. (to room only) — 74694. (to room only)
Sensible heat ratio = 0.97 — 52510. Less Internal Gain

Humidification load due to infiltration: 0.

Air Quantities		Temperatures		Check Figures	
Room Supply	3470.	DTR (Input)	20.0	CFM/ft²	1.9
Room Exhaust	0.	DTR (Actual)	20.0	Cooling, BTUH/ft²	41.9
Room Return	3470.	HTR (Input)	50.0	Cooling, ft²/Ton	286.6
Minimum AC/Hr	0.	HTR (Actual)	0.0	Heating, BTUH/ft²	40.4
Minimum CFM/ft²	0.00	Ret. Air (Peak Hr.)	75.0	AC/Hr.	12.5
Required OA CFM ***	0.0				
Room area =	1850.	Room volume =	16650.	Cooling Design DB	75
				RH%	50
				Heating Design DB	70
				RH%	0

* Indicates inside shading is closed.
** This load to return air includes both transmission and solar.
*** Used to determine OA flow at system level. Actual OA to room depends on room supply air flow and % outside air for the system.

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ROOM **501** **South Ext. A-K** SYSTEM **AHU-1** TERMINAL

Room Name	Peak Mo/Hr	Sens. C. Load	Total C. Load	Sens. Ratio	Room CFM	Heating Load	Room Area	CFM /ft²	Nr. Peop.	DT Htg.
501	11/13	74851.	77451.	0.97	3470.	74694.	1850.	1.88	13	0.0

Hour	8	9	10	11	12	13	14
Sensible	* Indicates inside shading is closed.						
Window Trans.	-8656.	-7324.	-4661.	-2663.	-666.	1332.	2663.
Window Solar	12793.	31699.	40821.	45228.	46944.	46442.	43597.
Wall Trans.	-4838.	-4094.	-2605.	-1489.	-372.	744.	1489.
Wall Solar	9838.	9046.	7549.	6412.	5286.	4149.	3396.
Roof Trans.	0.	0.	0.	0.	0.	0.	0.
Roof Solar	0.	0.	0.	0.	0.	0.	0.
Partition.	0.	0.	0.	0.	0.	0.	0.
Floor	0.	0.	0.	0.	0.	0.	0.
Infiltration	0.	0.	0.	0.	0.	0.	0.
Lights to Room	8280.	9463.	9463.	9463.	9463.	9463.	9463.
People	2708.	3250.	3250.	3250.	3250.	3250.	3250.
Equipment	9471.	9471.	9471.	9471.	9471.	9471.	9471.
TOTAL SENSIBLE	29597.	51511.	63288.	69672.	73376.	74851.	73328.
Latent							
Infiltration	0.	0.	0.	0.	0.	0.	0.
People	2600.	2600.	2600.	2600.	2600.	2600.	2600.
Equipment	0.	0.	0.	0.	0.	0.	0.
TOTAL LATENT	2600.	2600.	2600.	2600.	2600.	2600.	2600.
(SF=1.00)							
TOTAL LOAD	32197.	54111.	65888.	72272.	75976.	77451.	75928.

Hour	15	16	17	18	19
Sensible	* Indicates inside shading is closed.				
Window Trans.	2663.	2663.	1332.	0.	-1997.
Window Solar	37469.	24059.	7360.	0.	0.
Wall Trans.	1489.	1489.	744.	0.	-1116.
Wall Solar	3417.	4238.	5880.	7261.	8785.
Roof Trans.	0.	0.	0.	0.	0.
Roof Solar	0.	0.	0.	0.	0.
Partition.	0.	0.	0.	0.	0.
Floor	0.	0.	0.	0.	0.
Infiltration	0.	0.	0.	0.	0.
Lights to Room	9463.	9463.	9463.	5914.	2957.
People	3250.	3250.	3250.	2167.	1083.
Equipment	9471.	9471.	9471.	4736.	2368.
TOTAL SENSIBLE	67222.	54632.	37500.	20077.	12080.
Latent					
Infiltration	0.	0.	0.	0.	0.
People	2600.	2600.	2600.	1300.	650.
Equipment	0.	0.	0.	0.	0.
TOTAL LATENT	2600.	2600.	2600.	1300.	650.
(SF=1.00)					
TOTAL LOAD	69822.	57232.	40100.	21377.	12730.

HEATING LOAD
for 2°F OSA

Window	49388.
Wall	25306.
Roof	0.
Partition	0.
Floor	0.
Infiltration	0.
Total	74694.

Summaries

Area	1850.	ft²
Volume	16650.	ft³
People	13	
Infiltration		CFM
BTUH/ft² Clg.	41.9	
BTUH/ft² Htg.	40.4	

	3470.	CFM
AC/Hour	12.5	
Htg. DT =	0.0	

SYSTEM **AHU-1** Variable Volume PEAK LOAD occurs at 1 PM, November

	COOLING LOAD			HEATING LOAD		
	Sensible	Latent	To RA	Losses	Int. Gain	To RA
Window Trans.	1332.		0.**	49388.		
Window Solar	46442.					
Wall Trans.	744.		0.**	25306.		0.
Wall Solar	4149.					
Roof/Ceiling	0.		0.**	0.		0.
Roof Solar	0.					
Partition.	0.			0.		
Floor	0.			0.		
Infiltration	0.	0.		0.		
Lights*	9463.		0.		9463.	
People*	3250.	2600.			3250.	
Equipment*	9471.	0.			9471.	
(SF=1.00)						
TOTALS	74851.	2600.	0. ***	74694.	22184.	0.

TOTAL HEAT 77451. (to room only) 74694. (to room only)
+ 0. Plenum or RA heat
Sensible heat ratio = 0.97 + 0. Ventilation
Humidification load due to infiltration: 0.
Humidification load due to ventilation: 0. 74694. Total + 0. Humidification
There are 0 additional duplicates of this system.
74694. Total

Ventilation Air (Air quantity used for ventilation load marked *)

Fixed CFM Input At						0.	
0.00	Pct. Supply Air	x	3470.	CFM	=	0.	CFM
0.00	CFM/Person	x	13.	People	=	0.	CFM
0.00	Air Changes/Hr.	x	16650.	ft³/60.	=	0.	CFM
0.00	CFM/ft²	x	1850.	ft²	=	0.	CFM
Sum of OSA required for all rooms in this system					=	0.	CFM

COOLING LOADS (SF=1.00)

	To Rooms		RA Plen		Dir To RA		Ventilation		Motor		Sys Anal Adj		Total
Sensible	74851.	+	0.	+	0.	+	0.	+	9923.	+	-5.	=	84769.
Latent	2600.	+					-0.			+	-292.	=	2308.

TOTAL COOLING LOAD 87076. BTUH 7.26 TONS
System cooling load calculated with contribution of systems analysis.

AIR QUANTITIES			CHECK FIGURES			
Supply air sum of room peaks	3470.	CFM	CFM/ft²	1.88	AC/Hr	12.5
Supply air at system peak	3470.	CFM	CFM/ft²	1.88	AC/Hr	12.5
Exhaust air	0.	CFM	Cooling	47.	BTUH/ft²	
			Cooling	255.	ft²/TON	
Infiltration (summer)	0.	CFM	Heating	40.	BTUH/ft²	
Infiltration (winter)	0.	CFM	Humidification	0.	BTUH/ft²	

Lights installed in rooms of system = 2775. Watts After diversity = 2775. Watts
Number of people in rooms of system = 13. After diversity = 13.

* Diversity factors, and/or occupant limit, if input, applied to these loads.
** This load to return air includes both transmission and solar.
*** Total Heat to RA and/or RA Plen reflects potential offset by Vent. CFM.